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ABSTRACT

This manual provides information needed to meet the standards for pesticide applicator certification. The document is a compilation of pamphlets and circulars which discuss forest management, control of undesirable woody plants, herbicides in forestry, diseases and insect pests, and equipment for pesticide application. (CS)

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COOPERATIVE EXTENSION SERVICE

University of New Hampshire

FOREST PEST CONTROL AND TIMBER TREATMENT

CATEGORY MANUAL

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

James S. Bowman

SE 024 022

This training manual is intended to provide you with the information you will need to meet the standards of the E.P.A. for pesticide applicator certification, and prepare you to take an examination given by the State of New Hampshire Department of Agriculture based on this manual. It is not intended to provide you with all the information you need for effective pest control. Additional information in the form of publications and short courses can be obtained from the Cooperative Extension Service.

This manual has been prepared by:

James S. Bowman, Extension Entomologist-Pesticide Coordinator, University of New Hampshire.

Jon P. Turmel, Ass't Extension Entomologist-Pesticide Applicator Trainer, University of New Hampshire.

in cooperation with:

Department of Entomology, University of New Hampshire.

Department of Resources and Economic Development, University of New Hampshire.

College of Agriculture, Pennsylvania State University.

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U.S.D.A. - Forest Service, S & PF.

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TABLE OF CONTENTS

Section 1
Introduction to Forest Management in N.H.

Section 2
Forest Resources and Herbicides
"A Guide to Control of Undesirable
Woody Plants"

Section 3
Herbicides in Forestry

Section 4
Forest Trees.....General Diseases

Section 5
Forest Insect Pests

Section 6
Power Sprayers, Power Dusters and
Aerial Equipment for Pesticide Application

Extension Circular 401 (Revised)

Introduction to FOREST MANAGEMENT in New Hampshire

Cooperative Extension Service
University of New Hampshire
Durham, New Hampshire

Introduction To Forest Management In New Hampshire

By

Roger P. Sloan
Robert W. Breck
Arthur G. Dodge. Jr.
Wilbur E. Thompson
Leslie B. Sargent
Roger S. Leighton

Revised by:

Roger P. Sloan
Robert W. Breck
Arthur G. Dodge, Jr.
John A. Conde
Leslie B. Sargent, Jr.
Roger S. Leighton

COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF NEW HAMPSHIRE
in cooperation with the
DEPARTMENT OF RESOURCES AND ECONOMIC DEVELOPMENT
STATE OF NEW HAMPSHIRE

January, 1975

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Contents

Where Is Your Land? 7

Why Own Forestland? 8

Types of Forest Growth in New Hampshire 9

Managing Your Land for Timber 11

Harvesting Your Forest 14

Wildlife Management 19

Management for Recreation 20

Managed Forest Land Is Conservation 21

Christmas Tree Management 22

Managing for Maple Sap Production 23

Management for Personal Privacy 24

Other Management Assets 24

Protecting Your Forest Lands 25

Marketing Forest Products 28

Forest Finances 30

Small Tools 32

Safety 32

Assistance to Forest Land Owners 32

Glossary 33

Additional Reading and References 34

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INTRODUCTION

Your New Hampshire forest land can serve you in many ways. Among the more obvious ones are the production of sawlogs, boltwood and pulpwood for sale to the forest industries. Christmas trees, fence posts, poles, piling and maple syrup for sale to the public are other products which we receive from forest lands. Other uses and benefits to be derived from your woodlot, although less tangible, are perhaps more important in the long run. Among these are wildlife production and habitat protection, soil and water conservation, flood protection, family recreation, and one other factor best described as pride of ownership. As you learn more about these products and something about woodland management, you will begin to see that in many cases you can "have your cake and eat it too" when you manage your woodland wisely.

Forests are our greatest renewable natural resource. You, the woodland owner of New Hampshire, have a real stake in the future. If this great resource is to be left for future generations to enjoy, you must use it more wisely than many who have come before.

This bulletin will raise many questions to which you must find answers before you can even begin to develop a management plan for your woodlot. This is not intended to be a technical bulletin of "how" and "what to do" on your individual woodlot. It is a general statement about New Hampshire forest lands; what they are, why they are here, and how we can all benefit from their wise management. It is not unusual to decide on one primary management objective and at the same time make it compatible with a half dozen secondary objectives.

In making your forest management decisions, you are strongly urged to seek professional forestry assistance. New Hampshire has a well-rounded program of county forester, industrial forester, and consulting forester advice with a primary goal of assisting you to better manage your forest. Your county forester can help you with your management decisions and will offer a limited amount of service in implementing your plans. He may recommend that you retain the services of a consulting or industrial forester if it appears that you will need more assistance than he can give within the limits of his county forestry program. You may obtain the names of these professional foresters by asking your county forester for a copy of the current issue of the *New Hampshire Forest Market Report.*

Knowledge of your forest can bring you many benefits.

WHERE IS YOUR LAND?

The ownership of land is constantly changing. Standard practice when buying a tract of land is for the seller (the grantor) to pass a deed to the buyer (the grantee). In addition to names, dates, witnesses and other data, the purpose of a deed is to record a written description of the tract or tracts of land. In most deeds this description has been copied from the previous deed and often has been the same each time the land has changed hands during the last one hundred years or more.

Many deeds have been poorly written. They give little or no data concerning length or direction of the boundaries. Deeds often provide inaccurate or outdated information. Trees and stumps that were described as corners or bounds many years ago no longer exist. Brooks have changed course, roads have been changed or land marks may have changed to obliterate the original bounds.

How accurate is your deed description? Can you or anyone else find all the bounds and boundary lines after reading it? Are the lines well marked and are the corner markers permanent? Will anyone be able to easily locate the property one hundred years from now?

Land is becoming more valuable. As time goes on, there are likely to be many questions over the correct location of boundary lines and corner markers. It is best to write a good description and prepare a map at the time land is purchased. Later, if an abutter should claim some of your land, deed accuracy will be important.

Surveying

Some land, particularly in cities, is extremely valuable. Here, surveying is done very accurately to hundredths of an inch and minutes and seconds of degrees. However, with rural land of many acres, an adequate property survey can be made with a good hand or staff compass and a 100 or 200-foot tape. If you cannot survey your own land to locate the boundaries, you should retain a competent surveyor. Consulting foresters are available to do surveying for woodland owners.

A good deed description requires a survey of the property. The map at the bottom of this page shows a typical tract of land with information to easily locate all boundaries and corners.

The deed description of the same tract reads:—"Beginning at a stone bound located on the north side of Old Town Road and approximately 200 feet east of Brook; thence, N 6° W, 800 feet along a blazed line to a corner of walls; thence, N 84° E, 1075 feet along a wall (430 feet) a fence (450 feet) and a wall (195 feet) to a corner of walls; thence, S 6° E, 325 feet along a wall to the end of the wall; thence, N 84° E, 425 feet along a fence to a stone bound; thence, S 45° E, 250 feet along a fence to a stone bound on the north side of Old Town Road; thence, westerly 1800 feet along the north side of Old Town Road to the point of beginning."

Boundaries

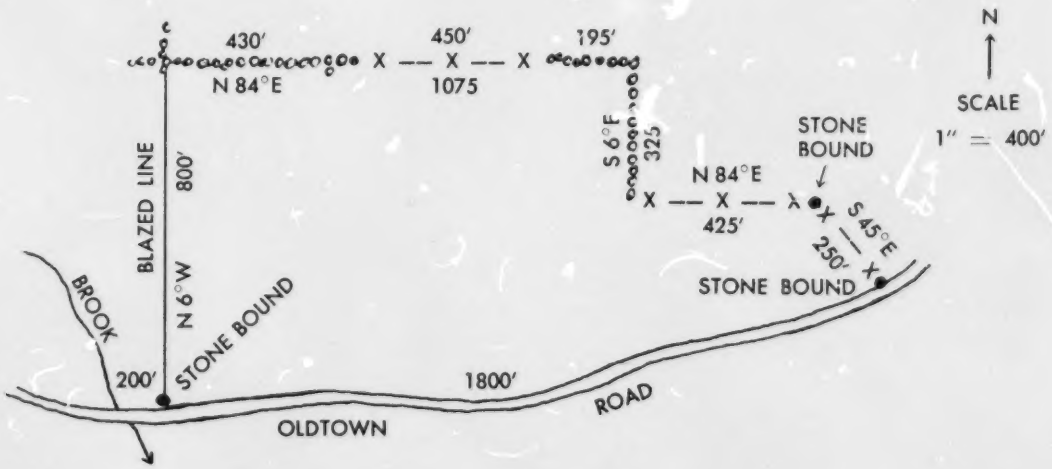
Stone walls are very common in New England. In many instances, a stone wall is the boundary line between two adjacent ownerships. They are quite permanent and easily found. Most walls were built a hundred or more years ago and before the advent of wire fencing.

Wire fencing has been used for boundary lines in recent decades but these are now deteriorating through neglect. Often they were not straight and were hung on convenient trees more or less along the actual boundary line. Where there is no permanent boundary line, it is best to run a straight line from one corner to the next, brushing the line out for clear sighting and blazing a sufficient number of trees along the line so as to be clearly seen. Blazes are usually made to face at right angles to the line:

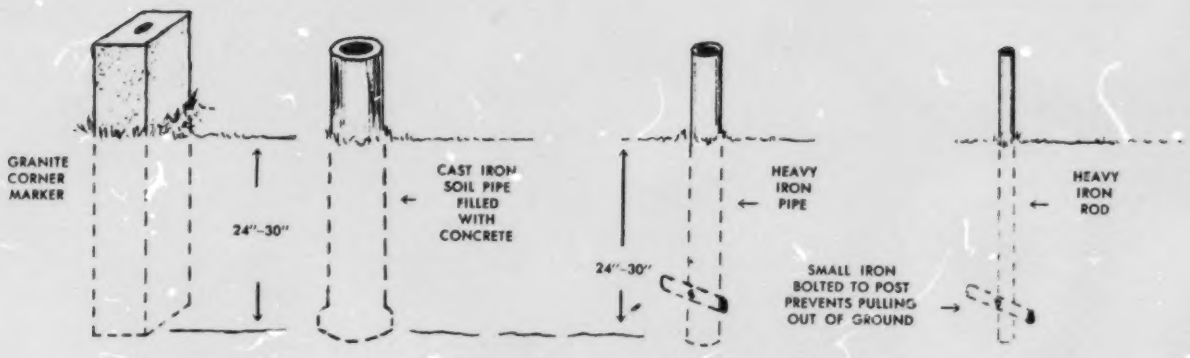
In open land where there are no trees and no permanent boundary lines, it is possible to set line posts at convenient distances of 100 to 500 feet along the line.

Corner Bounds

A corner bound is a point at which two or more boundary lines meet. It should be as permanent and easily located as possible. The best bound would be a granite post. Heavy iron stakes (1-2 inches in diameter) or heavy pipe (2-4 inches in diameter) also make good corner markers. Set boundary markers two to three feet into the ground, if possible. Piling rocks around the marker will help support it and identify it.



VARIOUS TYPES OF CORNER MARKERS


GRANITE CORNER MARKER
24"-30"
CAST IRON SOIL PIPE FILLED WITH CONCRETE
24"-30"
HEAVY IRON PIPE
SMALL IRON BOLTED TO POST PREVENTS PULLING OUT OF GROUND
HEAVY IRON ROD

Filing Deeds and Maps

When you have purchased a tract of land and have received the written deed from the grantor, you should file the deed with the Registrar of deeds at the court house in the county where the land is located. Your deed is copied or photostated and filed with many others. There is a small charge for recording the deed. Your original deed is returned to you. Keep your deed in a safe place, such as a safe deposit box. It is a valuable document.

Maps are quite often drawn to show boundary lines and the location of buildings, rights-of-way, springs, wells and other subjects pertinent to the tract of land. These maps can also be filed with the Registrar of Deeds. Some registrars specify the size of paper on which maps are drawn for recording. You should check on this before drawing such a map.

Surveyors in action.

WHY OWN FORESTLAND?

Roughly 70 percent of the commercial forestland in New Hampshire is composed of small woodlots and private holdings of less than 5,000 acres each. 70 percent of these owners hold 100 acres or less.

In the past, these woodlands were used to supply forest products for the owner's use or for sale. Although this is still partially true in northern New Hampshire, the management objectives of many New Hampshire forestland owners are changing. In addition to owners interested in forest products, many people are buying rural homes which include woodlands. Others are buying forestlands for retirement homes with supplemental income possibilities. Still others buy woodlands or land surrounding their homes for protection or for control of their environment.

Some owners with a rural background have an intimate knowledge of their trees and woodlands. Many others have urban backgrounds with little or no such knowledge but are very concerned, however, with the conservation of their woodlands. Both types of owners wish to develop them for reasons such as recreation, wildlife, income and natural beauty. Why do you own your forestland? Owners must become acquainted with their woodlands either by personal examination or through an agent. Outstanding features such as streams, vistas, and wildlife areas must be noted and evaluated for alternate uses. In many cases, the same area may be used for dual purposes, such as hiking, wildlife and natural beauty.

You will find that much of your forestland lacks the features needed for special uses. These areas will permit the growing of timber products. There will be no conflict with other objectives. Timber growing will be possible in many areas of special concern through carefully controlled cutting, slash disposal and woods road location.

In planning for multiple uses, the need for development or lack of development must be carefully considered by the owner. You must avoid changes which will harm or destroy the present tree growth and ground cover essential for a special need. Forestland can usually

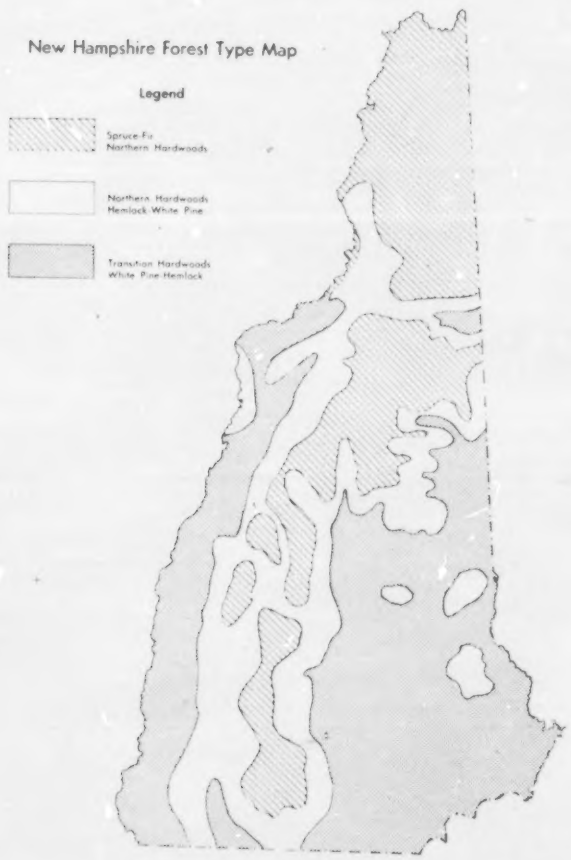
be managed to serve several purposes. You will have to establish priorities to which all other activities will be secondary. You may expect no timber income from some of these restricted areas. Your benefits from them will accrue from personal satisfaction. If the primary objective is income, you can still plan management restrictions that will prevent serious conflict with other uses and protect the general appearance of your forest.

County foresters are familiar with multiple use of woodlands. They will help owners decide whether present tree growth and natural features meet the owner's objectives and help plan the development of their woodlands.

TYPES OF FOREST GROWTH IN NEW HAMPSHIRE

Trees are the natural vegetative cover in New Hampshire. If man had not interferred with this growth, practically 100 percent of New Hampshire's land would be yielding trees. Even today, more than 200 years since man arrived in the state, about 85 percent of our land area still supports some kind of forest tree growth.

New Hampshire forest type map.



The wise landowner plans his forest management activities.

Your New Hampshire woodlot rests in one of the following three general forest type zones as shown on the New Hampshire Forest Type Map.

Transition Hardwood: White Pine-Hemlock Type

This kind of forest contains white and red pine, hemlock, red and white oak, white and/or black birch, red (white) maple and large tooth aspen as principal commercial species. These species will be found in varying mixtures depending upon localized conditions. The transition hardwood, white pine-hemlock forest type is usually found growing at elevations from sea level to 1000 feet on moderately well-drained to very well-drained soils. Some excessively well-drained soils at elevations closer to 1000 feet support good quality stands of this variety. Topography is usually flat or gently rolling to moderately steep. This forest type is most often found in the southern-central and the east-central sections of New Hampshire and the Connecticut River Valley.

Northern Hardwoods: Hemlock-White Pine Type

This forest category may contain sugar and red (white) maple, hemlock, white and yellow birch, white pine, American beech and/or red oak as principal commercial species. You may also find small stands of white ash or spruce-fir within this area.

A forest of this kind grows on the lower and middle slopes of the White Mountains and at elevations from 500 to 2500 feet above sea level. The soil supporting this forest type will be moderately well-drained to somewhat poorly-drained. At higher elevations, this type will be found on well-drained soils, probably because of the lower average temperature. Topography here is moderately rolling to very steep.

The species composition in this forest type will also vary due to localized conditions. However, there will always be a high percentage of hardwood trees.

Northern Hardwoods: Spruce-Fir Type

White and red spruce, balsam fir, sugar and red maple, yellow and white birch, beech and white ash are the commercial species in this type. This growth is found in the cooler parts of the state at elevations above 1000 feet and on higher slopes of the mountainous areas. Soils are moist and cool varying from poorly-drained to moderately well-drained. Topography in this type spans the spectrum from flat to very steep. Again, species composition will vary locally. You will find pure stands of spruce-fir, nearly pure stands of hardwoods, or a combination of both.

We must emphasize that man and natural calamities do alter conditions within a given forest type. Therefore, the general character of your forestland may vary from the conditions described here. For example, a logger may have cut all the merchantable sugar maple growing in a woodlot within the northern hardwood, hemlock, white pine type.

The important fact to remember is no matter which forest type your land is in, proper forestland management will yield high quality, desirable wood, and thereby provide a substantial profit.

Above, typical spruce-fir, northern hardwood forest type. International Paper Company land, Philip's Brook, N. H. Below left, typical northern hardwoods, hemlock-white pine forest type. Bascomb land, Acworth, N. H. Below right, typical transition hardwoods, white pine-hemlock forest type. Avery land, Wolfeboro, N. H.

Weeding a young stand of white pine. This man is removing the unwanted trees so that the white pine crop trees can grow faster. Chemicals can sometimes be used for more efficient weeding.

MANAGING YOUR LAND FOR TIMBER

The production of a crop of timber requires a relatively long period of years. This time is referred to as a rotation, extending from the time of establishment to harvest. This period may be as little as ten years for Christmas trees, forty years for pulpwood, fifty to one hundred years for white pine sawlogs, and as much as one hundred twenty years for hardwood sawlogs. In any case, it is the care that your forest stand receives during this growth period that determines the ultimate quality and quantity of the harvest.

The Forest Growth Period

The care and treatment of a stand of timber from the time of establishment to final harvest is referred to as *silviculture*. While the term agriculture means "field culture", the term silviculture means "forest culture".

The silvicultural treatment of a forest stand during the growth period is referred to as timber stand improvement (T.S.I.) or woodland improvement. More specifically, the terms weeding, releasing and thinning are used. These practices are carried out during age periods as follows:

PRACTICE	AGE OF STAND	TYPE AND DIAMETER OF TREES
Weeding	5-20 years	Seedling, Sapling — 1" - 4"
Releasing	15-30 years	Pole — 4" - 8"
Thinning	25 plus	Pulp, Sawlog — 8" plus

Although weeding, releasing and thinning are quite specific practices as shown in the above table, there is no exact timetable to indicate just when one practice should end and another begin. Quite often the natural forest growth is such that all these practices may be carried out simultaneously on the same acre. You may hear these terms used interchangeably. To better grasp the improvement practices, the following explanations and recommendations are given.

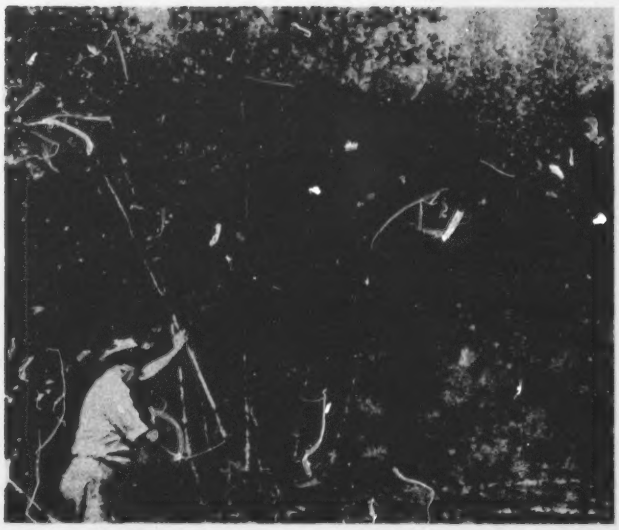
Weeding

Weeding is the first management practice in a stand of very young trees, five to twenty years of age. The objective is to remove undesirable species that are crowding and overtopping the potential crop trees. Weeding improves the composition of the stand. You will want to keep these suggestions in mind when weeding.

1. Do not weed too early. Seedlings of desirable species should average at least waist high and be well established.

2. Weed areas where there are sufficient seedlings of desirable species. At least 200-400 trees, averaging 10 to 15 feet apart, well distributed per acre, are necessary. This number of trees per acre may decrease somewhat with height and size.

3. Weed out only what is necessary to bring the best trees through the next 5-10 years. Allow the tops of the most valuable trees full space, but keep the sides somewhat crowded with smaller trees so that the understory will remain dense to assure self-pruning of lower limbs, straight stems and protection against snow and ice.



These pictures show a forest stand before and after releasing. Note that crop trees are now free to grow. Jonelle Forest, Canterbury, N. H.

4. Remove inferior trees and brush which may damage desirable trees.

5. Do not spend time weeding in areas that are unproductive. Very shallow, droughty or very wet soils are not likely to produce enough growth to warrant the expense of improvement practices.

6. More than one weeding may be necessary, particularly on good sites where growth is very rapid.

Releasing

Releasing is the second step in timber management when stands are 15 to 30 years old. This is the further removal of inferior trees to improve growing conditions of crop trees and to further improve species composition.

The following recommendations will help you complete releasing operations:

1. Remove trees of poor quality that are crowding or overtopping desirable crop trees.

2. If the stand is receiving its first treatment (weeding was not done at an earlier stage), potential crop trees should be well distributed throughout the stand to warrant the expense. At least 150 such crop trees per acre spaced about 17 feet apart must be present. If weeding has been done previously, sufficient crop trees will be present.

3. It is not necessary to remove small inferior trees that are below the crowns of crop trees. They act as "trainers" and "whips", thus keeping live limbs on the crop trees from growing too large and also helping to assure self-pruning of lower limbs.

Remove only what is necessary to gain rapid growth of the crop trees during the next five to ten year period.

5. A second releasing may be needed to maintain rapid growth and to improve the composition of the stand.

Thinning

Thinning is the removal of trees from dense stands to gain faster growth of trees that will be held another 30-50 years. Thinnings every five to ten years are needed to maintain maximum growth and continually improve quality until final harvest is reached.

The rules below can be applied to all thinnings:

1. Locate and designate potential crop trees. On well-stocked stands, this should average 100 to 200 trees per acre, approximately 15-20 feet apart.

Thinning will be needed in this stand within five to ten years. Future crop trees have been pruned to a height of 17 feet (trees 1, 2, 3). Pitch pine (4) could be classed as a cull tree. Lindsey land, Deerfield, N. H.

2. Remove those trees which are interfering with or preventing rapid growth of the crop trees.

3. In commercial thinnings remove other trees not likely to survive until the next thinning.

4. Frequent light thinnings are better than occasional heavy thinnings. Thinnings approximately every 10 to 15 years for a period of 50 or 60 years may be needed to reach maximum growth of the final crop trees.

5. Early thinnings in stands under 42 years old may not yield any salable products. Later thinnings will yield more salable products.

Cull Tree Removal and Stand Improvement

One of the first improvement practices which you may apply in a previously unmanaged stand is to eliminate the cull trees. The better quality trees which remain will have more room to grow. A cull tree is usually old and large, having been left from earlier logging operations. Such trees are often very limby, crooked or rotten and have little or no economic value. It may cost you less to kill such trees than trying to cut them down for usable products. Felling such trees may also cause extensive damage to adjacent trees of good value.

Killing cull trees is done either by girdling or by frilling and applying chemicals. Girdling is usually done with an axe or chain saw, removing a chip of bark and wood completely around the tree. This severs all living tissues between the roots and crown of the tree. Frilling is done by making single connected axe cuts around the tree and then applying a chemical to kill the tree.

Even if a complete job of girdling is done, it may take as long as five years for the tree to finally die. Frilling with chemicals approved by the New Hampshire State Pesticide Board can result in much earlier mortality. Some species are more easily killed than others.

Slow killing is quite often better than an immediate kill. If the change from shade to direct light is too sudden some of the adjacent desirable trees may be damaged. This is often the case with white pine. Shaded trees with thin, tender bark will often sunscald if suddenly exposed to direct sunlight. Sunscald or sunburn may kill a vertical strip of bark and expose the tree to disease and rot.

Soon after a girdled or frilled tree dies, the twigs and small branches begin to fall off. The larger limbs fall next and finally the tree, usually rotted at the stump, will topple over. It may be many years before the tree is completely gone. The slow process of decaying and falling apart will do a minimum of damage to new growth coming up under it. In addition to releasing new growth the dead tree may foster wildlife as a dead tree in the area.

Pruning

Pruning is the removal of limbs from young trees to provide future high quality butt logs. Trees chosen for pruning will ultimately be the crop trees for harvesting at the end of the rotation.

The proper time for pruning is when trees are pole-size (4-10 inches D.B.H.). The trees selected should be straight, thrifty and dominant in the stand. If selected trees are not dominant they must be released to assure rapid growth.

White pine is the species most often pruned. In pure stands as many as 100-150 trees can be pruned per acre. 100 pruned trees per acre gives a spacing of approximately 20x20 feet.

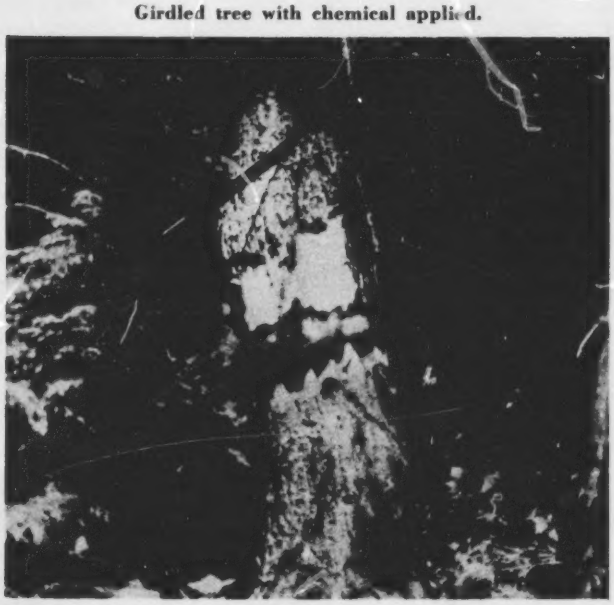
Selected hardwood and spruce trees can also be pruned. Usually there are fewer hardwood crop trees per acre. Hardwoods have fewer limbs to remove per tree because they tend to lose dead limbs after they die.

Some do's and don'ts:

1. Do prune with a saw. There are several types of pole-saws available on the market.

2. Don't prune with an ax.

Girdled tree with chemical applied.



Frilled tree with chemical applied.

Picture of a person pruning a crop tree.

3. Do saw limbs off flush with the trunk of the tree.

4. Do not prune over one-third of the live branches of the tree.

5. Do prune in cold weather when pitch and sap will not run and tender bark will not be torn from the trunk of the tree.

6. Do select trees with a straight stem that can be pruned to a height of 17 feet. This allows for stump height and the final harvest of a 16 foot sawlog. If you are unable to locate a tree to prune to 17 feet, choose a tree which can be pruned to 15, 13, 11 or 9 feet.

HARVESTING YOUR FOREST

The owner who has been managing his forest for many years knows that harvesting is the most critical period of management. Unfortunately many new owners do not realize that a mistake in harvesting cannot be easily corrected. Most serious mistakes in management are frequently made at harvest. All too often the decision as to the best method of harvesting is left to the judgement of the person who is buying the product.

The mechanics of harvesting roundwood forest products consists of cutting down the tree and removing the limbs (felling), cutting the felled tree into usable lengths (bucking) and moving the tree to a landing or yard (yarding) where it can be loaded on a truck to be hauled to market. Felling and bucking are done by a woodsman armed with a power chain saw and possibly an axe. Yarding is done with either a crawler tractor, a rubber tired skidder or occasionally with horses. Since few New Hampshire forestland owners are in a position to harvest their own forest products, there is no need here to discuss the details of how trees are cut and removed from the woods.

The forest land manager is concerned with maintaining and conserving a forest crop for the future. It is with this in mind that the forester examines a woodlot *before* harvesting begins. His concern for reproducing desirable species as well as upgrading the quality of the residual forest is reflected in the method he prescribes for carrying out the harvest.

There are two broad silvicultural systems under which all roundwood forest products are harvested, namely, "clearcutting" and "partial cutting".

Clearcutting

CLEARCUTTING is the removal of all merchantable trees. Uncontrolled clearcutting usually results in damage to the unmerchantable trees left standing. It is seldom advisable to clearcut your forest unless the overall quality of merchantable trees is so poor that they are not worth holding for future growth. Clearcutting can be done in some Spruce-Fir stands where the trees have grown too closely together. They will have small crowns and are dependent upon each other for support. It can also be justified in some cases of managing hardwoods. Clearcutting is done to obtain reproduction of desired species such as Yellow Birch. In all cases of clearcutting each decision should be made based on silviculture and economics.

Partial Cutting

PARTIAL CUTTING is the removal of a limited number of trees which are considered merchantable.

Partial cutting meets the needs of many small wood-

An operator with tractor, boom and scoot used for yarding forest products. This type of equipment is used mainly on small land ownerships.

Typical clearcutting. There are no salable products left except the land. Ohlson land, Conway, N. H.

land owners. The forest is left in a more attractive condition. Financial returns are more frequent when trees are cut periodically on a planned program. It is also easier to manage for other uses such as recreation, wildlife, etc. with a controlled partial cutting program.

There are several methods of partial cutting. The most common are individual tree selection, strip cutting and small group selection. INDIVIDUAL TREE SELECTION calls for marking selected single trees for harvest. The forester marks those trees which will yield a good financial return to the owner. He must also consider the goal of upgrading the residual stand. Individual trees will be marked to make room for a future crop. STRIP CUTTING is the clearcutting of narrow strips through a stand at predetermined intervals. The strips are not usually more than 100' wide and are laid out at right angles to the prevailing wind direction. This relationship to the prevailing winds insures a good distribution of seeds over the cut area and reduces the risk of windthrow. SMALL GROUP SELECTION means selecting small groups of trees to be removed throughout the forest. The objective is to reproduce desirable species from adjacent seed sources. Usually the groups will be cut from one fourth to one acre areas. They should be distributed in such a manner as to reduce the threat of wind-throw in uncut sections.

Be sure to contact your county forester before harvesting your timber.

Forest Aesthetics

Many woodland owners express deep concern about the appearance of their woodland during and after harvesting. A timber sale agreement can require that tops be lopped and the lot be left in a satisfactory condition. This is discussed very thoroughly in a publication of the University of Massachusetts Cooperative Extension Service. Publication No. 440, titled, "Timber Harvesting and Forest Aesthetics," by John H. Noyes, Professor of Forestry.

Natural Regeneration

When you harvest timber from your forest you usually will establish a new crop of trees. If special provisions are not made for regeneration, nature will do it her own way. What you do and what you get as a new crop of trees will largely determine the future of your forest.

Our forest trees produce seed crops of varying degrees periodically. Sometimes, less preferred species produce the heaviest crops.

The parent seed trees may be single trees or groups of trees. The more numerous and vigorous the seed trees, the better the probability of securing a good crop of seedlings. Seed trees of weed or unwanted species should be eliminated.

The seed will vary in size from the very small ones of birches and poplar to heavy nuts produced by oak and hickory. Some of the smaller and lighter seeds will be blown for considerable distances. Many will be carried by wildlife and birds. This may account for scattered small clumps or single trees differing from their neighbors.

The survival of the seedlings growing from these seeds will depend on the soil where they fall. Easy access to mineral soil, adequate moisture available to the roots of the seedling, and protection from excessive sun or drying winds are necessary for their survival. Fortunately, most trees produce an excess of seeds to insure the survival of the species even though birds and animals may consume a large portion of the crop. Other trees and shrubs may act as "nurse" trees to provide the shade and wind protection which will permit the seedlings to become established.

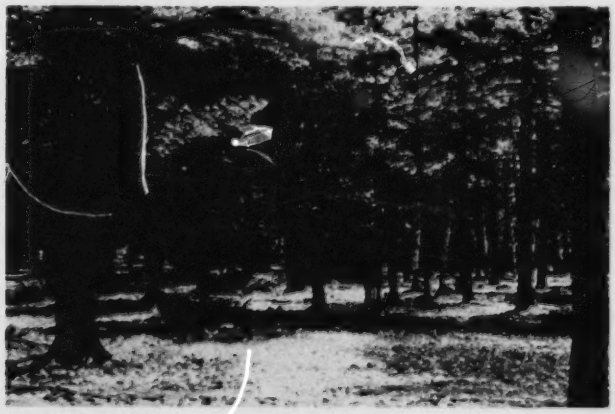
One of the most serious obstacles for germination and survival is a thick, dry layer of needles or leaves covering the ground. This will prevent the germinating seed from reaching mineral soil and an adequate water supply. You can assist in the establishment of your new

Trees have been harvested from this woodlot on an individual selection basis. Morrill Tree Farm, Conway, N. H.

Group selection has been done here. Note the groups of trees left standing. Johnson Forest, Deerfield, N. H.

A strip cutting has just been completed on this area.

Moody Park, Claremont. This area was logged for sawlogs and fuelwood three years before this photo was taken.



tree crop by preparing the site so that tree seeds will find a favorable environment. A good method is to scarify the soil with some type of rake or harrow. This will expose the mineral soil and make a better seedbed. Logging operations on bare ground will sometimes serve this purpose. Where there is a dense grass or shrub ground cover, some of the appropriate silvicides or herbicides can be used to surpress the competition. These chemicals can be broadcast or applied in strips or spots.

Natural seeding or regeneration is the least expensive. It yields trees which are already adapted to the area, and usually results in an excess of seedlings which permits a wide choice later on for crop tree selection.

Artificial Regeneration

Frequently, the area to be reforested lacks seed trees of desirable species or is an open field, pasture or borrow area. In this case it may be necessary to plant trees. Planting gives you the opportunity to establish an even-age crop of preferred species.

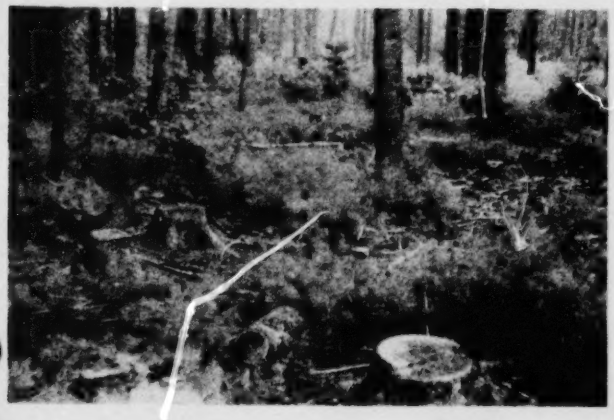
The soil and the planting site will determine the tree species which should be planted. Consult your county forester for this information. He can tell you what kinds of trees will best suit your plans for the area. He can also advise you as to the best spacing for each species and each use. While a six by six foot spacing is recommended for white pine and Christmas trees, red pine is planted eight by eight feet, and larch may have an even wider spacing.

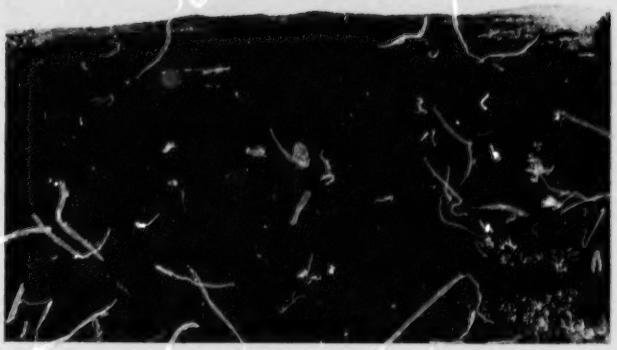
Table—Number of Trees Per Acre at Different Spacings in Feet

SPACING BETWEEN ROWS	Spacing Within Rows						
	4	5	6	7	8	10	12
12	908	706	605	519	454	363	302
10	1089	871	726	622	544	436	
8	1361	1089	908	778	681		
7	1556	1245	1037	889			
6	1815	1452	1210				
5	2178	1742					
4	2722						

When planting open areas bordered by seed bearing trees of desirable species, it usually is not necessary to plant to the edge of the woods. A strip equal to the height of the bordering trees may be left to seed naturally.

Brewster Morrill Tree Farm, Conway, N. H. Note natural regeneration under this mature white pine stand.





A well planned and managed Christmas tree plantation.

You may have areas, particularly with a dry sandy soil, which are partly stocked with weed trees such as gray birch. These areas may be underplanted with pine, either red or white, leaving the birch as a temporary cover. This will protect the pine seedlings from excessive sunlight. When the pines grow to the point where they are being damaged or retarded by the birch, a releasing will be necessary.

As with natural regeneration, your planted seedlings have a better chance of survival in heavy sod or ground cover if you perform some type of site preparation. You may use some suitable type of chemical treatment, either by liquid spray or granules to deaden the competition in strips or spots. A very shallow furrow laid out along the contour in sod land also makes planting easier and frees the seedling from the grass competition for several years. Where it is difficult to use mechanized equipment, the removal of a small patch of sod, one foot square, with a grub hoe or mattock will also assist in the planting. Land shaping may be needed in borrow pits before planting. Consult your county forester for further information on methods, materials, and application.

If the competing growth is rangy such as scrub oak, bear oak, or gray birch, mechanical clearing or prior chemical treatment will make it much easier to plant and give the seedlings more growing space.

When you have a large acreage of old fields which are relatively level and smooth, you will find a tree planting machine will do the job quickly and economically. These machines require an adequate tractor for pulling power and several men to do the planting. They are efficient only in smooth relatively clear fields.

As most planting jobs are on small and generally rough acreages, hand planting is usually the most practical method. The "grub hoe" or mattock is the tool most commonly used. There are specialized planting spades or "bars" which are helpful if you expect to have a large planting program.

Most people will use nursery stock either from private nurseries or from the state forest nursery. These seedlings should have strong bushy roots and tops which will encourage vigorous growth. Some other people, due to scarcity or cost of the desired species, may use wild seedlings. These must be lifted carefully to extract all the roots possible. Torn or broken roots are a serious drawback in the use of wild seedlings.

We recommend waiting for two years to plant softwood seedlings in an area where there is fresh pine slash. An insect, the Pales weevil, lives in this fresh

Rugged seedlings grown at the New Hampshire Forest Nursery, Boscowen, N. H. These are ready to be lifted and sold for forest planting.

This machine is making a furrow to reduce root competition and is direct seeding at the same time. Hand planting could be done instead of direct seeding.

slash and will attack and may kill any softwood seedlings in the area. Further, any area where you plan to plant white pine should be checked for the presence of white pine blister rust. Your county forester can help you have your area checked.

Direct seeding is a new approach to reforestation which is receiving much attention. It is necessary to use seeds which have been treated with a bird and rodent repellant to prevent their severe loss. Planting seed spots in partly stocked areas using hand tools or planters was the earliest application of this method. There has been loss of seedlings from smothering by needles and fallen leaves. Broadcast seeding from the air has been used to restock large burned areas. A combination of site preparation and seeding by a bulldozer and seeder or similar equipment such as a forest fireline digger has shown the greatest promise.

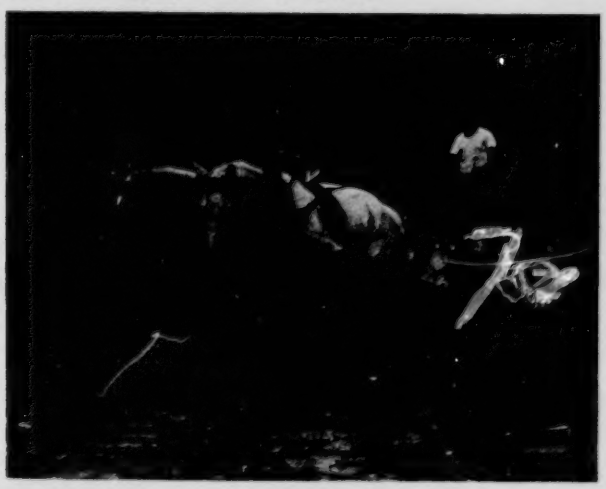
Both planted and natural seedlings are often damaged by wildlife. Mice and rabbits will eat the bark, killing the seedlings. Deer eat the twig tips and damage the stems by "horning." Many birds will eat the buds thereby deforming the trees. A partial remedy is to leave wildlife food in the planted area. Many conifers are considered as survival food for wildlife. Leaving preferred food materials will divert animals and birds from the planted seedlings.

In any stand of young trees, you will find young hardwoods which are crowding and retarding the growth of the preferred seedlings. These can be controlled by brush killing materials now available. Similar materials can be used to control grass and shrubs which are particularly harmful in Christmas tree plantations. Your county forester can suggest the materials and methods of application to help you control the weed growth affecting your seedlings.

These practices are generally successful in protecting appearances and speeding recovery after logging. Also, there are advantages in terms of fire protection and opening up an area for regeneration.

This is the type of yarding equipment most often seen working in New Hampshire forest lands today.

Horses and scoot yarding logs. This type of equipment is almost past history in New Hampshire.



MANAGING FOREST LAND FOR OTHER USES

Wildlife Management

WHAT IS WILDLIFE MANAGEMENT

Wildlife or Game Management is the art of making land produce sustained annual crops of wildlife for recreational use. Originally, recreation was considered the harvesting of game by hunting and trapping. Today, people also derive pleasure from the sense of husbandry or good resource conservation. This includes wildlife and timber production.

Who Owns the Game in New Hampshire?

All native game animals are the property of the people of the state of New Hampshire. Migratory species are public property and come under federal regulations as well as those of the state. The New Hampshire Fish and Game Department is charged with the responsibility of protecting and developing this important resource. In the case of migratory game, they work jointly with the United States Fish and Wildlife Service.

The oldest and one of the most important types of wildlife management concerns the regulation of the harvest of game species. In New Hampshire this is done through passage of fish and game laws by the state legislature. The laws are enforced by your local conservation officer on both private and public lands.

You, as a private landower, are the most important individual in determining the production of wildlife. You control the range or habitat with respect to available food and shelter on your land. Public ownership of game and the high percentage of private ownership of the wildlife range has created many problems. Many hunters and fishermen believe they have the legal right to use all private property when in pursuit of game or fish. The landowner believes he has the right to determine who uses his land and for what purposes. Your conservation officer will be glad to explain your rights as a landowner. He is also prepared to assist with some wildlife management problems.

Good wildlife range. You can see three of the major game ranges in this picture: agricultural land and food patches, abandoned agricultural land, and forest lands. This is all on one hundred acres or less.

Status of Game Management on Private Lands

Most of the development of good game habitat on private lands has been the result of other good land practices such as timber, agricultural or water management. There are two important exceptions to this rule. One is the deeryard management program on private land in northern New Hampshire, sponsored by the New Hampshire Fish and Game Department. The other is a number of water fowl refuge programs on private land. These exist through agreement with the landowners and New Hampshire Fish and Game Department.

Types of Game Range (Habitat)

Each game species shows a preference for a specific range or land use area. There are five major ranges:

1. Active agricultural fields
2. Abandoned fields and pastures
3. Forest lands
4. Aquatic habitat (ponds, lakes, and streams)
5. Swamps and marshes

Some species such as the whitetail deer may use all or a portion of each of these ranges. Generally, the most productive places for wildlife are those containing all five ranges in a relatively small area. The area between ranges is called "edge," and here can be anticipated the greatest concentration of game.

What You Can Do To Improve Habitat

1. Carry out good agricultural, forestry and wet land use practices. This improves the habitat for all wildlife.
2. Plan for and set aside special areas for wildlife; for example, deer wintering areas that are used year after year. These locales require special forestry practices to maintain and improve the area for deer.
3. If you have interests in one species of wildlife or in a special group of wildlife, land use practices should be aimed at improving their required habitat.
4. Develop an over-all game management plan for your lands and work it into your forestry and other land use plans.
5. Game or wildlife management requires technical knowledge of species and their habitat. You should make use of all technical services and literature available before attempting to carry out a wildlife management program on your lands.

Source of Technical Assistance Available to Landowners on Game Management

1. New Hampshire Fish and Game Department, Concord, New Hampshire
2. Local conservation officer
3. Your county forester can recommend the proper agencies with which to work on wildlife management problems.

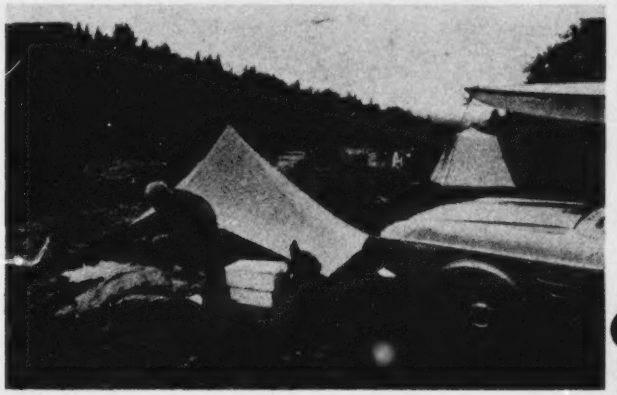
MANAGEMENT FOR RECREATION

Millions of Americans are finding themselves with more leisure time and greater amounts of extra income. What to do with this leisure time? For many people, the out-of-doors has become a focal point for recreation. As a result, many forest recreation facilities are being taxed beyond their capacities.

Your forest land may offer a chance to increase your income and relieve part of the heavy demand for forest recreation. Some of your land may be suitable for camp grounds, picnic areas or hunting and fishing areas. If so, this can provide more income from your woodlands.

The development of private forest recreation facilities is not a simple matter. There are many factors which can affect success. You should carefully consider these facts before committing yourself to any recreation development: (1) Do you have the ability to meet and serve the general public? (2) Is your land close enough to major transportation routes and population centers? (3) What is the demand in your area for this type of recreation development? (4) Are you willing and able to build, manage and maintain such a development? (5) What is the cost of constructing such a development? (6) Can you finance the operation on the anticipated rate of return from the business?

The American public needs and demands forest areas for recreation. Your forest land may provide income from this growing business.



Vista cleared on private land in Charlestown, N. H. Overlooks Connecticut River and Mt. Ascutney in Vermont.

MANAGED FOREST LAND IS CONSERVATION

Conservation has been defined as the "wise use" of resources. This implies that some choice between alternative uses has to be made. For example, what is the goal of owning a woodlot? This question has to be answered by the owner or by those making decisions for the owner.

If an owner is not under pressure for immediate income, his plan of use may delay current income. He may wish to build up future income through better forest management. Timber stand improvement through partial cuttings can accomplish this.

An owner may be satisfied with holding his woodland for sentimental, aesthetic, or other reasons, and income may be given little or no consideration."[1]

"The majority of private woodland owners are not motivated by the monetary returns from the sale of forest products or services but by more intangible values such as aesthetics. Most of today's landowners have a non-rural background; however, they have a strong desire to learn woodland lore which, in general, tends to make them excellent conservationists."[2]

Some of the above comments may fit your land management situation. If so, you may wish to contact the town conservation commission. They can inform you of their program for better land use conservation. Your well-managed woodlands can contribute to the town conservation effort by providing greenbelts, wildlife habitat or by protecting stream banks or creating a scenic area.

With a major percentage of New Hampshire's forest land in private hands, your forest land management is very important to the over-all state-wide conservation effort. Your county forester can help you find areas in your woodlot that may be of interest to your conservation commission.

Private forest land creates a green belt in this town.

[1] Adapted from Forest Notes, No. 88, Economics and Conservation, by J. R. Bowring, Professor Resource Economics, University of New Hampshire.

[2] Adapted from material prepared by Roger Leighton, Strafford County Forester, on "Forest Land Use Management."

This American Chestnut tree should be protected.

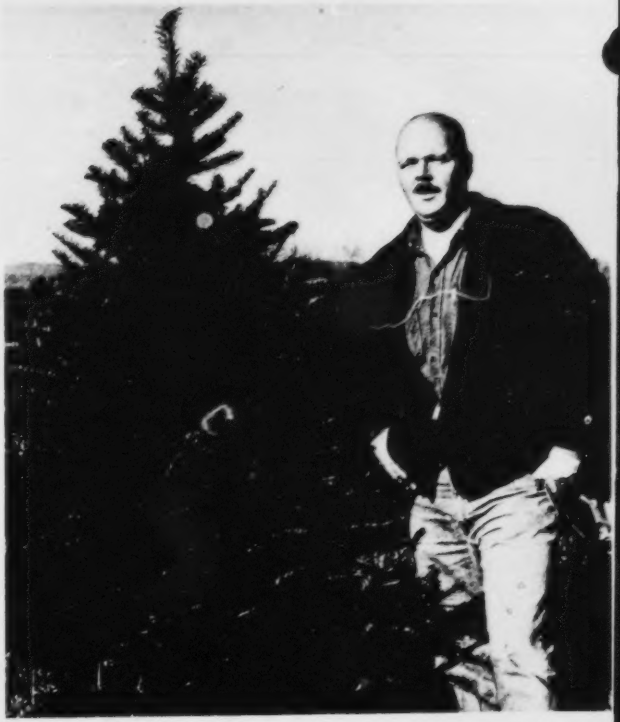
Native wildflower protected by private landowner.

CHRISTMAS TREE MANAGEMENT

A special forest crop that you may wish to consider in your over-all management plan is the production of quality Christmas trees. After several years of intensive management, some forest landowners are realizing as much as one hundred dollars per acre annually from the sale of Christmas trees. This kind of return is usually realized on small areas of five to ten acres that have been under intensive management. This area is set aside solely for growing Christmas trees. Pruning, shearing, fertilizing and controlling brush are needed several times before harvesting. Application of certain herbicides to control grass and brushy competition is necessary.

If you do not have a stand of wild trees that can be managed for Christmas trees, you may decide to plant some trees on "idle" or abandoned land. Species most commonly planted in New Hampshire for Christmas trees are: balsam fir, white spruce, fraser fir and Scotch pine. A period of ten to twelve years must be planned for your Christmas tree crop.

Christmas trees are sold wholesale and retail at roadside or on the stump. They can be sold either individually or by volume. If your plantation is located near an urban area the former method can be employed and a nice profit realized. Trees located several miles from a population center would most likely be marketed roadside at wholesale rate.



A high quality balsam fir.

28

Maple operation. Good quality sugar maples tapped with plastic tubing to carry the sap to a central collection point. Clark Sugarbush, Langdon, N. H.

MANAGING FOR MAPLE SAP PRODUCTION

While considering the management of your forest, you should not overlook the value of producing maple sap for our maple syrup industry. The owner of sugar maples does not necessarily have to boil the sap and produce maple syrup to profit from his trees. He can sell his sap to one of the syrup producers who pay for sap brought to their sugar house. If an owner is unable to tap his own trees, he can often arrange to lease the trees to others who are looking for more taps. In New Hampshire, only a very small percentage of our accessible sugar maples are being utilized for maple production. We are not producing enough syrup to meet existing demands. Many producers prefer to utilize their time and effort to convert the sap to syrup rather than gather sap. The skill and investment required to produce sap is much less than that required to produce syrup. All these conditions make it favorable for you to supplement your income by selling sap to the maple syrup producer.

The profit made from tapping sugar maples varies from year to year. There are many factors which effect annual sap yields and sugar content. Since payment is usually based on sugar content and quality, it is better to tap the sweetest trees that produce the greatest volume. Roadside trees and those growing in the open usually are better producers than trees growing in a dense woodlot. They are usually at least one per-cent sweeter and produce a larger volume. Gross values of sap reported by producers in southern New Hampshire range from $.34 to $1.01 per tap. Earnings of $2.31 per hour after deducting operation costs were reported. A conservative estimate of value received per year from an average sugar maple is at least five times greater for sap production than for timber production.

In New Hampshire, most maple syrup is produced from the sap of the sugar or rock maple (Acer saccharum). Other species of maple which can be used are the black maple (Acer nigrum), red maple (Acer rubrum), and the white maple (Acer saccharinum). The sap of the black maple is comparable to sugar maple but this species is found only in limited numbers in this state. Although the red maple and the white maple produce sweet sap, it is normally not as sweet as that produced by the sugar maple. It is also reported that their sap may have a tendency to produce excessive amounts of sugar sand and a darker syrup. The red maple and white maple also bud out earlier than the sugar maple. This decreases the length of the period for sap collection.

If you are going to produce syrup for reasons other than a hobby, the maple lot should contain at least 500 taps. The minimum size tree to be tapped is 10 inches in diameter at breast height (4½ feet above the ground). As a rule of thumb, you can figure on an additional tap for each 6 inches added to the tree's diameter. If you wish to produce sap for sale, the number of taps needed to make it profitable would be lower. The accessibility of the taps and the distance to the sugar house purchasing the sap would then become limiting factors.

Quite often when a landowner desires to sell sap to a syrup producer and the number of taps is not too great, the producer will loan the equipment to tap the trees. Cost sharing from the agricultural conservation program is available for improving old sugar bushes and for weeding, thinning, and releasing younger stands of maple.

If maple sap or syrup production is of interest to you, contact your county forester. He will outline the possibilities on your forest lands.

This is a well constructed multiple-use forest road. Samuel Abbott Forest, Milford, N. H.

MANAGEMENT FOR PERSONAL PRIVACY

Perhaps you have acquired your forest land to be sure that you and your family may maintain privacy. Owning large acreage as part of your "homestead" does prevent new building construction near your home but does not always provide privacy. If absolute non-use of your forest land is your objective, constant patrolling is the only answer. This method is very time consuming and difficult. Many of the management suggestions in this bulletin will help you to limit access to certain sections of your forest land. Natural screening of access roads can be planned, chemical weeding and thinning can make cross-country travel difficult, proper water bars can limit normal types of vehicular travel, logging slash can control movement within a logging area or become a barrier to public access.

Complete non-use of your forest land by the public may not ultimately be the best objective. Carry on a good "public relations" program. Inform people that some areas can be used but others should not be used because of your objectives. You may find the public quite cooperative. Conservation-minded people who use the land for non-paying recreation may help you in fire prevention, trail maintenance and protection of certain natural areas or natural regeneration.

Your county forester and conservation officer can help you with suggestions along these lines.

OTHER MANAGEMENT ASSETS

We have discussed the management of your forest for wood and fiber production and special products. There are additional assets which can aid you in management and add to the enjoyment of your woodlands. These are roads, trails, bodies of water, vistas, and special interest areas. If you have a special forest based interest, be sure it is considered in any plan for your woodlands.

Roads and Trails

Easy access to all parts of your woodlands is essential. A permanent all weather road system will transport you quickly to any section. Improvement work, harvesting and protection from fire and pests, will cost less. It will be easier for you and your friends to merely enjoy the woods. This may be only a single track road.

You can also plan and build temporary roads designed for harvesting products. These should be located to avoid erosion and permit re-use for future harvesting. These roads would be maintained for periodic rather than continuous use.

A trail system may also increase accessibility and enjoyment. These will cost less for construction and maintenance than all-weather roads. They can provide excellent routes for horseback riding, snow-mobile travel and hiking.

Another well-constructed multiple-use forest road. Note ditch at right.

Water Bodies

Rainfall and ground water provide moisture for the growth of your trees. Ponds, streams and water holes provide water for fire protection, wildlife, personal recreation and aesthetic enjoyment. These water areas may be natural ponds and marshes, or may be dug or dammed.

If possible, your permanent road system should be located near water for effective forest fire control. Most of these water areas will be for multiple use. Primarily, they might be for a private fish pond, a swimming pool, or private water supply. Incidentally, they will be attractive and provide water for fire protection. Your county forester can help you determine these functions and obtain assistance in their development.

Vistas

New Hampshire is a panorama of varied natural beauty for the enjoyment of its residents and visitors. Much of this beauty is obscured by unrestricted tree growth along roadsides and in old fields or pastures. You may not wish to reforest all old fields and pastures, but you should consider an alternate use for them such as vista or recreation areas. Harvesting cuts may be made to reveal desirable views.

A vista does not need to be a broad expanse. It may be a framed woodlot view of a small pond, a rock formation, or a group of trees. Determine what you feel would make a good picture.

Special Interest Areas

More and more people own woodland for reasons other than growing timber. There are many special items they will want to consider in their management program. Sometimes special trees of distinctive size, shape or species will be kept. Unusual or attractive plant and flower areas may be protected. Tipping stones, caves, and other rock formations are of great interest to many people. Many woodlands show evidence of former land use in stone walls, roads, cellar holes and burying grounds. A little research may prove that there is historical significance in these sites.

If these special areas are of interest to you, they should be selected and clearly defined. You should make their preservation an item of concern in your plans. For example, care must be taken with plants and flowers to maintain the present shade and moisture environment.

PROTECTING YOUR FOREST LANDS

There are certain risks in owning and managing forest land. Your forest can be damaged or destroyed by many things both natural and man-made.

The destruction of forests by fire has been widely publicized by Smokey the Bear. Other types of forest

Damage to young softwood stems by deer. Wildlife like to eat tender shoots and twigs such as these.

destroyers are insects, disease, wind, ice, snow, grazing and not least of all, man. Let's consider some of these hazards and how you can avoid excessive damage to your forest land.

Insects and Diseases

Insects and diseases destroy more timber each year than all the other factors combined. Each species of tree has its insect and disease enemies. You cannot eliminate insects from your forest but you can minimize their destructive effects. A healthy forest usually will remain in this condition just as a healthy, well-fed family does. Insects and diseases prey on the weaker trees in a forest stand first. As their numbers increase, they attack the stronger, healthy trees. During weeding, thinning and harvesting operations, you should eliminate the weak or defective trees. This will help keep insects and disease under control.

How do you recognize unhealthy trees? They will usually have defects on them. Bark will be damaged on the trunk or cankers will ooze sap or pitch. Short needles or small sickly leaves indicate that a tree is not healthy. In many cases you can see where insects have fed heavily on the leaves, needles and twigs. Your county forester will point out other symptoms to look for as he examines your woodlot with you.

Some common insects and diseases which can be damaging to your woodlot are:

INSECT	HOST TREES	DAMAGE
White Pine Weevil	Eastern White Pine and Spruces	Kills leader of tree
Birch Leaf Miner	Gray and White Birch	Discolors leaves Slows growth
Spruce Gall Aphid	Norway and White Spruce	"Pineapple" type gall on branches
Spruce Bud Worm	Spruce and Balsam Fir	Defoliates trees
Gypsy Moth	Hardwoods and Softwoods	Defoliates trees
Balsam Wooly Aphid	Balsam Fir	Kills trees
Tent Caterpillar	Hardwoods	Defoliates trees
Oak Twig Pruner	Oaks	Kills twigs and branches

DISEASE	HOST TREE	DAMAGE
Dutch Elm Disease	American Elm	Kills Tree
Nectria and Strumella Cankers	Many Hardwoods	Damages trunk; can kill tree
White Pine Blister Rust	Eastern White Pine	Damages trunk, kills tree
Anthracnose	Hardwoods	Kills leaves Slows tree growth
Needle Blight and Needle Casts	Softwoods	Kills needles Slows tree growth

Serious insect and disease attacks can often be prevented by recognizing symptoms of their presence in your woodlot at an early stage. Your county forester and other professional foresters are always on the watch for insect and disease damage. If you have a question about the possibilities of infection in your forest lands, contact them.

Forest Fires

New Hampshire's fire prevention and protection record is excellent. Very little forest land has been destroyed by fire since 1954. Fire fighting techniques and communication systems have been constantly improved.

Fire is always a danger to your forest land but you can help to minimize that danger. A few suggestions for accomplishing this are:

1. If the ground is not covered with snow you must have a burning permit from your town fire warden or local fire chief when having *any* fire outdoors.
2. Teach your family, friends and others who occupy your land the proper use of fire. Inform them where and when it is safe to use fire.
3. Inform your local Fire Department and Fire Warden of:
   a. Good access roads
   b. Available water
   c. Available machinery to fight fire, if you have it. (i.e.) bulldozers, trucks, shovels, back pack pumps.
4. Minimize flamability of slash by keeping it close to the ground where it will stay moist and decay rapidly.
5. Maintain woods roads so that modern forest fire fighting equipment can proceed onto your property.
6. Remember, only you can prevent fire.

Damage from Wind, Snow, Ice and Other Natural Factors

Protecting your forest from damage by Mother Nature is very difficult. No one knows when nature will become a destroyer of property. Breaking or uprooting trees by wind, snow or ice is a hazard inherent with forest ownership. Maintaining a healthy forest by proper cultural work will help to lessen damages from natural causes. Just as with insects and disease it seems to be the less healthy stands which are most seriously damaged by natural causes.

Grazing by Wildlife

A heavy population of wildlife can eliminate young forest trees. In New Hampshire our wildlife populations do not often build to a point where their grazing damages the forest. Most wildlife prefer hardwood species and will only be damaging to conifers in such places as deer or moose yards. Winter yards are necessary for our wildlife to survive the rugged northeast winters. The total acreage damaged by wildlife in New Hampshire is very slight.

If you have a young hardwood forest you need to recognize grazing as a hazard until the young trees have grown beyond the reach of the animals. Hardwood timber species in New Hampshire usually reproduce in great quantities. This leaves plenty of potential crop trees as well as enough forage for wild animals.

If you are planting valuable species such as black walnut, you will have to protect the young seedlings from wildlife by fencing, repellants or other methods.

Grazing by Domestic Animals

Grazing of domestic animals on forest land can be beneficial under controlled conditions. Be sure to consult your county forester if you are planning to graze your forest.

Damage to Your Forest by Man

Historically, man has run a close second to insects and disease as the greatest destroyer of forests. Man's fame as a destroyer has come from his well-known carelessness with fire and thoughtless use of resources. An increasing population and an increased use of our forest land means greater possible damage to your forest by man.

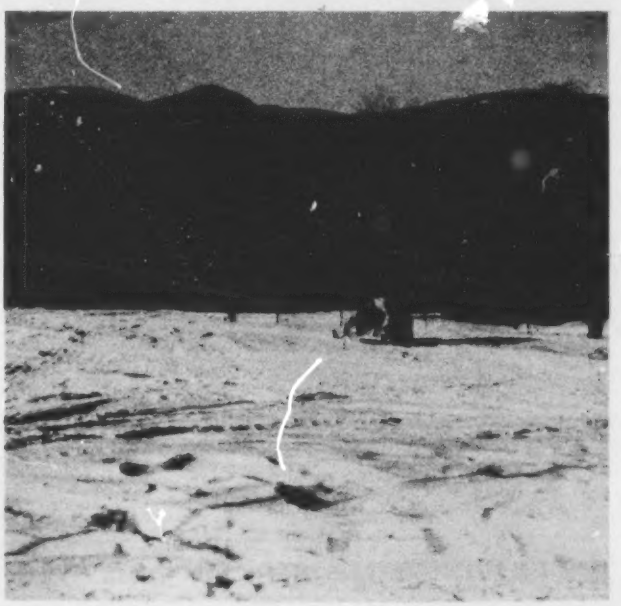
A. Snow Vehicles:

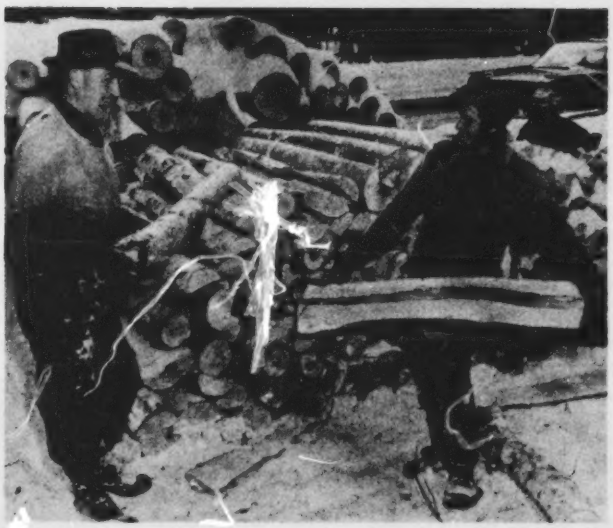
Indiscriminate driving of these popular vehicles damage young plantations in open fields. This is especially true where the young tree tops are at or near snow level.

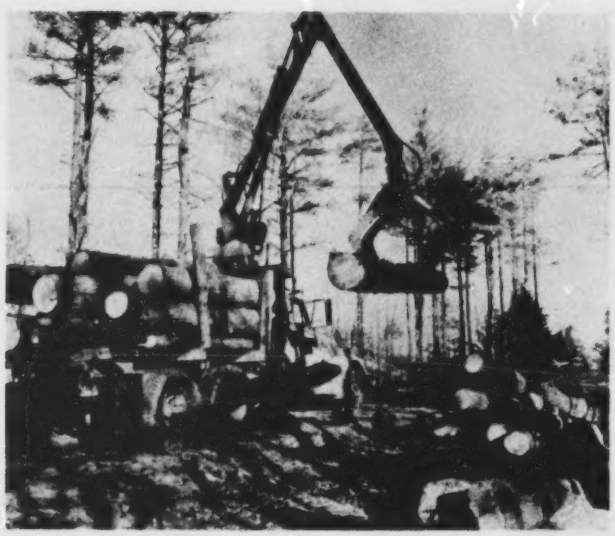
Much damage can also be done to natural reproduction below snow level if snowmobile drivers do not know the value of these young trees.

You can prohibit the use of these vehicles on your property. It may be more to your advantage to contact the local snowmobile clubs and work with them to plan trails which can be used. Require the club to publicize the driving area. Be sure "snowmobilers" know you are cooperating. Before opening your property for public use, check to see what your liability will be.

Snowmobiling is fun but can damage young forest stands.







B. Soil Erosion:

Exposed soil on steep slopes can cause erosion problems which will make forest land management difficult. Proper planning and location of logging and access roads will prevent most soil erosion problems from occurring.

C. Soil Compaction:

Heavy foot or vehicle traffic over a long period of time can compact the soil covering tree roots. The effect of this is to stop air and water from percolating through the soil to the roots. Lack of available moisture and air will slow tree growth or cause serious damage.

D. General Tree Damage:

Man is continually breaking branches, peeling bark, and hacking trees with his axe while he is in the forest. This is a hazard that a woodlot owner must face. Activity of this type can be minimized by proper public relations. Forest protection is a part of forest land management. It is necessary and should be planned along with the remainder of your operations. Your forester will be glad to help solve specific protection problems.

MARKETING FOREST PRODUCTS

At some time during the management of your forest you will have products to sell. Marketing special products such as Christmas trees and maple syrup is fully described earlier in this material.

In this section we will discuss the sale of trees large enough for round wood products.

"Round Wood" includes :

1. Pulpwood—wood used for paper or fiber products. This is usually sold on a cord or weight basis and is bucked into four foot lengths.
2. Boltwood—similar to pulpwood but has to be much better quality. This wood is used for the production of dowels and turnings. It is usually bucked into short lengths (39"-54") and will average smaller in diameter than pulpwood. Boltwood is sold by the cord.
3. Logs—logs are made from mature trees and are usually sold by board foot measure. One thousand board feet is the standard unit of measure. Logs are sold in 8, 10, 12, 14 and 16 foot lengths plus 3 to 4 inches. The usual end product from logs is lumber or plywood.
4. Poles, Posts and Piling—these are special products that are usually sold on the basis of straightness, special length, and/or species.
5. Fuelwood—there is increased interest in fuelwood because of the higher price of fuel oil. Fuelwood is usually split, or of smaller size than pulpwood, and sold in shorter lengths. Units of measure are based on the cord but vary from single fireplace logs to multiples of a cord.

Above left, pulpwood being delivered to a pulp mill in northern New Hampshire. Center picture, fitting fuelwood for the market in Carroll county. Note fuelwood is split white birch. Boltwood in background is high quality wood. It is not split. Left, white pine logs loaded for mill delivery in southern New Hampshire.

pulpwood, and sold in shorter lengths. Units of measure are based on the cord but vary from single fireplace logs to multiples of a cord.

You will sell most of your roundwood as stumpage. Stumpage means the sale of standing trees in the forest before they are cut. These sales are convenient because most landowners do not have the specialized logging equipment to handle roundwood products.

When you sell stumpage you should know what products your trees will produce. The type of roundwood determines your stumpage price.

The following preparitory steps are involved in a stumpage sale:

1. The trees or area to be cut must be clearly marked. This insures that all parties involved know exactly what is to be sold.
2. At the same time, an estimate of the total volume is made. This places the buyer and seller on "equal footing" when agreeing on the sale price of the products.
3. A contract is written and signed by the buyer and seller. This describes the terms of the stumpage sale and the responsibilities of all parties concerned.
4. The harvesting operation is supervised to insure that all terms of the contract are met.

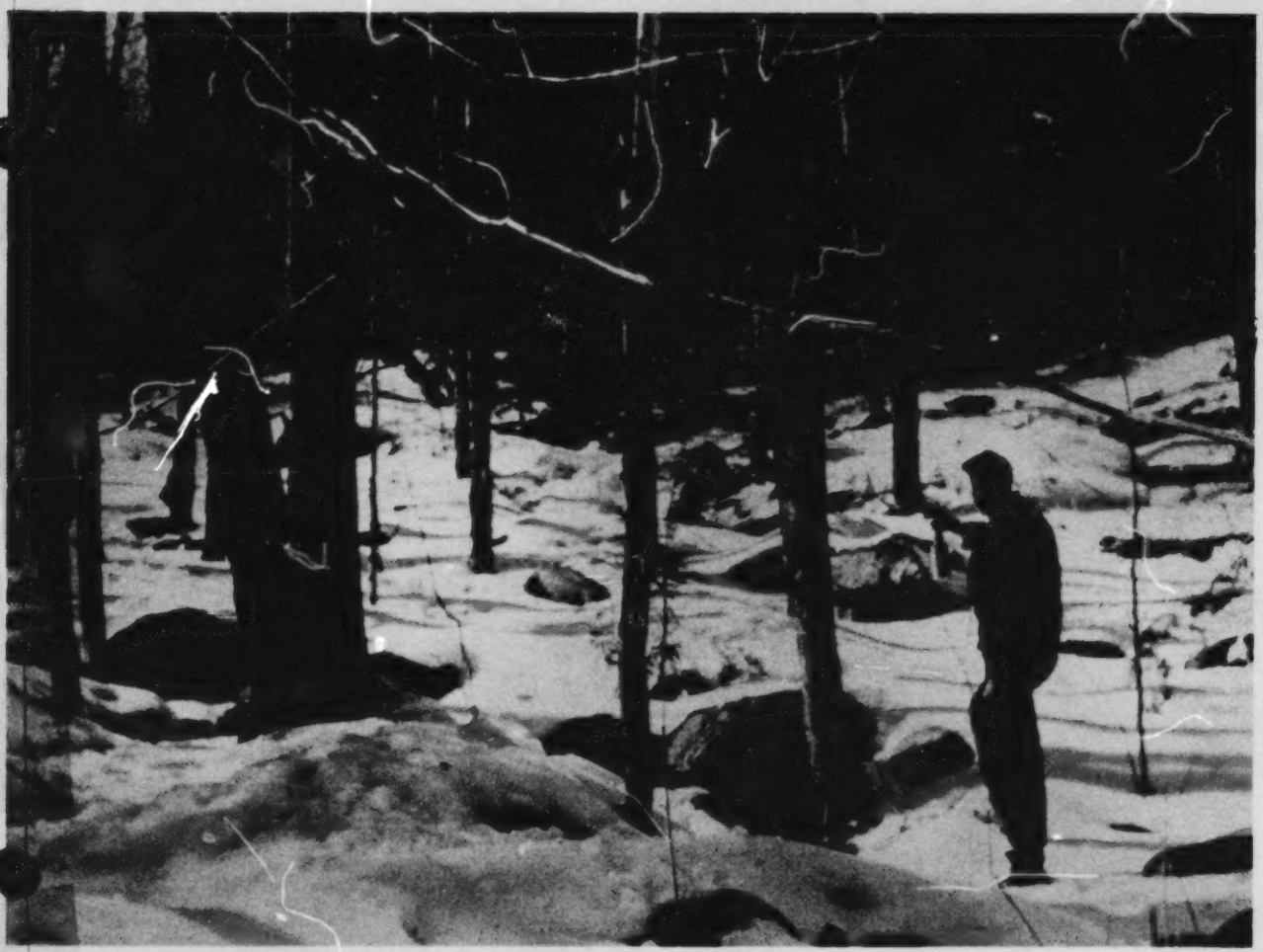
Your county forester can teach you how to market your forest products.

If you cannot complete all steps in the marketing process you should employ a consulting forester. He will act as your agent. Consulting foresters are professionally trained and are in business to serve their client's best interests.

The demand for forest products fluctuates. Prices for your products will be based on this demand. It is a good idea to plan your timber sales to take advantage of the markets.

The products that you grow and harvest are going to be more and more important to New Hampshire forest industries. Virgin forests with huge volumes of timber have long since disappeared. Industries now depend on the small woodlot to supply both quality and volumes of raw material. The products that you grow create jobs, pleasure and many necessities of life.

This forester is preparing his client's stumpage for sale. Notice the paint marks at ground and eye level. Evans lot, Sandwich, New Hampshire.



WOOD PRODUCTS FROM CARROLL COUNTY, N.H.
This Utilization Is Accomplished Using
Established Principles
tiple-Use Forest Land Management
COOPERATIVE EXTENSION SERVICE CARROLL COUNTY, N.H.

The trees that you grow may become one or more of the products shown in this picture. Your tree may become a good book, a house, or a piece of fine furniture.

FOREST FINANCES

Financial aspects of woodland ownership probably vary in as many ways as there are owners. In New Hampshire, during the last few decades, there has been a change in objectives of forest ownership. Today people own land for protection, recreation, aesthetics or stewardship. Financial return is not always the main objective.

If woodland is owned for income from forest products you must consider costs and returns over a period of many years. Forest land investment differs somewhat from investments in securities or savings accounts. A small woodlot under management will produce dividends periodically rather than annually.

The ideal woodlot is one containing timber of all ages. This will allow a sustained yield management pro-

gram and timber can be harvested periodically for as long as one wishes. Cuttings are not necessarily made at regular intervals. You may cut only when higher prices are being paid or when specialty markets are buying high value products.

When considering the production of forest products as an investment, it would be wise to compare alternative investments.

Taxes

If you own forest land, property taxes must be paid each year. In most cases the taxes on forest land are reasonable; however, the demand of increased populations and higher costs are causing much woodland to be valued for higher uses. Often these higher valuations result in taxes greater than the return you can expect from forest products.

Under New Hampshire statutes a stumpage owner must pay a yield tax when the timber is cut. Normally, the buyer assumes this expense.

Expenses

Expenses are costs of improving your forest land. Improvements may include planting, weeding, releasing, thinning, pruning or building access roads and forest fire ponds. Higher gross return from greater volume or better quality will be your objective for improvement expenses.

Incentive Programs

Under the National Agricultural Conservation Program, administered by the Agricultural Stabilization and Conservation Service, you can receive incentive payments for woodland improvement. Planting, weeding, releasing, pruning and fire protection measures such as ponds and access roads are included in this program. Payments vary somewhat from county to county. It is best to consult with your county forester or contact the County Agricultural Conservation and Stabilization Office about this program.

Income Taxes and Expenses

Two types of expenditures are involved in the cost of forest ownership. The first kind is capital expenditures for acquisition of land and timber and improvements or equipment with a useful life of more than one year. The second type is annual expenses paid or incurred during the year.

Capital expenditures are generally recoverable over a period of years by depletion or depreciation. Annual operating expenses may be deducted from gross income. Space does not allow for a complete explanation of income taxes. We refer you to: *"The Timber Owner and His Federal Income Tax," Agricultural Handbook No. 274, USDA, Forest Service.* This may be obtained from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402, for 35 cents.

Investment Return

If you have decided to invest in forest land to produce forest products, it may be helpful to visualize some aspects of management and the time required to produce timber products.

The following table indicates by decades the sequence of periods in the rotation:

0-10 years	—	Establishment. The seedling and sapling period. Some weeding and releasing may be needed.
11-20 years	—	Further weeding and releasing to assure good growth of desired trees.
21-30 years	—	Pole-sized timber. Begin to select crop trees. Thin out some unwanted trees. Prune selected white pine and hardwoods.
31-40 years	—	Continue thinning to improve stand composition and quality. It may be possible to obtain some merchantable products from these thinnings.
41-50 years	—	Continue thinning. Small sawlogs, pulpwood and fuelwood will often pay for this improvement work and yield a small profit.
51-60 years	—	Improvement cutting. Further removal of the poorest trees to allow maximum growth of the best trees. Sawlogs will yield some profit.
61-70 years	—	Further improvement cutting.
71-100+ years	—	Selective cutting of final crop of highest quality trees. The crop may be harvested in one cutting or in several partial cuts over a period of ten to twenty years. White Pine saw timber may be economically mature in 70 years. Hardwoods may require 100 years or more.

In many instances, a tract of forest land has stands of timber that vary in age. Some stands may be young and may require improvement work. Generally, this is a total expense with no immediate return. Other stands may be middle-aged or older where improvement cutting and selective cutting will yield immediate profits.

The final returns on an investment will depend on many factors. Some factors that effect returns are:

1. The point in time when you invest relative to the total rotation of your forest crop.
2. The quality of the site; is the land good or poor?
3. The amount of high quality timber that is harvested at the end of the rotation. Will there be a high percentage of select lumber and veneer logs or will it be all low grade lumber, fuelwood and pulpwood?

Forest finance is no more complicated than that of many other businesses. Profits from forest products can be sizeable. Some New Hampshire woodland owners with fairly small holdings (200+ acres) report profits of more than 6 per-cent a year. You will find that multiple-use forests tend to yield higher profits.

SMALL TOOLS

The forest land owner has an excellent opportunty to accomplish much in his own woodlot to increase the growth and quality of timber.

It is not expected that large-scale logging operations will be carried out by the average owner. However, much improvement work is needed in young stands and this can be done with a few simple tools. Hand tools are quite inexpensive. A good chain saw is perhaps the most costly item the average small woodland owner need acquire.

The basic tools are an axe and a saw. There are a few other useful tools that will help. The following list should assist you.

AXE—two and a half or three pound for general chopping.

HATCHET—for girdling or frilling.

SAWS—Bow Saw—a hand saw with a 24 to 30 inch blade, for cutting small trees or for bucking small logs or fire wood.

Pruning—pole saws to prune selected white pine or hardwoods for potential crop trees. DO NOT PRUNE WITH AN AXE. Pruning saws are made with rigid or telescoping poles from 4 to 12 feet long. Blades are curved rigid or straight hacksaw-like.

Chain Saw—there are many good makes on the market. A light weight model with a 16-inch blade is perhaps best. There are some very small light weight models as well as heavy duty ones. A forester or chain saw dealer can help you select the best one for your needs.

WEDGES—for felling and splitting. Felling wedges are made of soft metal, plastic or wood. Splitting wedges are made of steel.

SPLITTING MAUL—a heavy sledge hammer-like tool to use with splitting wedges. One head is wedge shaped for splitting cordwood.

ACCESSORY EQUIPMENT—proper files and guages are necessary to keep a chain saw in proper working order. A small whetstone should be handy for sharpening an axe.

SAFETY

Always be careful when using equipment in the woods, particularly if you are alone. Stand on the opposite side of a log when chopping. Be especially careful with a chain saw. Do not use it except when you are standing firmly on the ground. Keep it free from brush and obstructions. Check your tools often to see that they are in topnotch working order.

ASSISTANCE TO FOREST LAND OWNERS

We have given you many suggestions for managing your forest lands. The problem now is to select and apply the ideas that meet your objectives. You may want further explanation of these to assist in making your decisions. In New Hampshire there are several sources of help available to the private woodland owner.

Public Agencies

Throughout this bulletin we have mentioned the county forester. He is a publicly-sponsored professional forester who conducts an educational program to assist you in managing your woodland. He can further explain various suggestions for management to help you make your decisions. He will recommend people who can provide services not included in his program.

There are fire, pest and disease research and control programs provided by the state for the protection of your woodlands.

The United States Department of Agriculture has two agencies which offer specific assistance to woodland owners. The Soil Conservation Service has soils information which is helpful in management planning. The Agricultural Stabilization and Conservation Service has cost sharing practices which pay some of the cost of specific forest improvement practices.

Your county forester can help you contact these agencies to take advantage of their programs. The names of agencies and their programs may change from time to time. In case of doubt contact the Cooperative Extension Service, University of New Hampshire, Durham, New Hampshire, or the New Hampshire Forestry Department, Concord, New Hampshire, and you will be referred to the right agency or individual.

Private Agencies

There are also private sources of information and assistance for woodland owners.

The Society for the Protection of New Hampshire Forests, Concord, New Hampshire, has bulletins and information on forest land management problems. It sponsors educational programs for school groups. It also promotes many other activities in the interest of forestry for woodland owners.

The Society is co-sponsor with the New Hampshire Timberland Owners' Association of the New Hampshire Tree Farm Program. There are other local forest-oriented associations throughout the State.

The New Hampshire Timberland Owners' Association provides its membership with assistance and information regarding forest landowner concerns such as marketing forest products and forest taxation.

These and other organizations such as the New Hampshire-Vermont Christmas Tree Association and the New Hampshire Maple Producers' Association offer activities and meetings for their members.

New Hampshire has a number of private consulting foresters who offer professional assistance to woodland owners. The names of these consultants and the services which they offer are available from your county forester, the State Division of Resources Development (Forestry) and the Society for the Protection of New Hampshire Forests.

GLOSSARY

ACP—Agricultural Conservation Program supervised by the USDA Agricultural Stabilization and Conservation Service. This is a cost-sharing program where the government shares the cost of timberstand improvement with the landowner.

ALL-AGED—Applied to a stand in which, theoretically, trees of all ages, up to and including those of cutting age, are found.

ANNUAL RING—The growth layer of one year, as viewed on the cross-section of a stem, branch or root.

BOARD FOOT—A unit of measurement to determine volume of lumber. One board foot = a board 12" x 12" x 1".

BUCK—To saw a tree into lengths after felling.

BUTT LOG—The first log in a tree. Usually of much higher quality than the rest of the logs in a crop tree.

CANOPY—The combination of tree tops which produces the shade in a forest stand.

CANT HOOK — CANT DOG OR PEAVY—A tool used for loading sleds and rolling logs onto landings.

CHOPPER—The basic member of a logging crew in the Northeast. He fells trees and makes them into logs or bolts.

CONSULTING FORESTER—A professional forester who provides forest land management services for a fee or a percentage of timber sales on his client's land.

CORD—A unit of measurement to determine cubic volume of round wood. Technically equal to 128 cubic feet. A pile of four feet round or cleft wood four feet high and eight feet long is considered to be full cord measure in New Hampshire.

COUNTY FORESTER—A professional forester employed by the Cooperative Extension Service of the University of New Hampshire in cooperation with the New Hampshire Department of Resources and Economic Development. The county forester is employed to teach forest landowners, forest industries and loggers modern techniques of forest land management. A county forester is located in each county extension office.

CROP TREE—A tree selected in a stand or plantation because of rate of growth, position or quality to be carried through to maturity. Growth of such trees is made the object of frequent thinnings or other improvement cuttings.

CROWN—The top of a tree. Usually referring to the live top.

CRUISER—Man who estimates and/or measures standing timber.

CULL TREE—A tree of little or no economic value due to poor form, limbyness, rot or other defect.

CULL TREE REMOVAL—Removing cull trees from a forest stand to improve the quality and growth rate of the residual stand.

CULTURAL WORK OR PRACTICES—A phrase which means the same as weeding, thinning, releasing, pruning or timber stand improvement.

DOMINANT TREE—A tree which usually has a large healthy crown that is part of the overstory. This tree will dominate its immediate area.

EVEN-AGED—Applied to a stand in which small age differences exist between individual trees. The maximum difference in age permitted in an even-aged stand is usually 10 to 20 years.

FOREST STAND or FOREST TYPE—A group of trees, occupying a specific area and uniform in composition, species, age arrangement and condition, as to be distinguished from other adjoining forested areas.

HARVEST CUTTING—Removing (in forest management), a crop or stand of financially or physically mature trees as a final cutting.

IMPROVEMENT CUTTING—A cutting made in a stand, past the sapling stage, for the purpose of improving its composition and character.

INCREMENT BORER—A steel instrument used by foresters to bore into a live tree and remove a core of wood to determine rate of diameter growth or condition of the wood.

INTEGRATED LOGGING—The production of different products from a stand and from individual trees.

LANDING OR YARD—A place where logs are assembled for loading and transportation to a mill.

MULTIPLE-USE—Managing the same area of forest land for several uses such as hiking, wildlife protection and timber production.

OVERMATURITY—That period in the life cycle of trees and stands when growth, or value, is declining.

PARTIAL CUTTING—A cutting by which only a part of the stand is removed. It usually implies a series of such cuttings.

PLANTATION—An area planted with forest trees.

PRUNING—Sawing branches from a tree. Purpose of doing so is usually to produce clear wood instead of knotty wood.

PULP HOOK—A short metal hand tool used in handling pulpwood.

REGENERATION—Young forest trees produced naturally from seed of mature trees.

RELEASING—Releasing is the second step in management when stands are 15 to 30 years old. This involves the further removal of inferior trees to improve the growing conditions of desirable trees and to further improve the composition of the stand.

ROTATION—The period of years required to establish and grow timber crops to a specified condition of maturity.

ROUNDWOOD—The same as logs, pulpwood or boltwood.

SAPLING—A young tree less than four inches in diameter breast-high. The minimum size of saplings is usually placed at one inch in diameter breat-high.

SCALE-SCALING—The measurement of logs or other forest products. Determining volume in bd. ft., cu. ft., cords or linear measure.

SCALER—The man who determines the content of a log in board feet or in cords.

SECOND GROWTH—Forests that originate naturally after removal of a previous stand by cutting, fire or other cause. A loosely used term for young stands. In the loggers language, the smaller trees left after a cutting, or residual trees available for another logging on the same area.

SEEDLING—A tree grown from seed. Usually the term is restricted to trees smaller than saplings. In nursery practice, a tree which has not been transplanted in the nursery.

SILVICULTURE—The art of producing and tending a forest; the application of the knowledge of silvics in the treatment of a forest; the theory and practice of controlling forest establishment, composition and growth.

SILVICIDE (HERBICIDE)—Chemicals used to kill or control unwanted trees or vegetative growth.

SKIDDING-SCOOTING-SLEDDING OR YARDING—Moving wood products from where they are cut to the landing or yard.

SKID TRAILS—Small trails laid out in the woods over which logs are pulled from the stump to the skidway or landing.

SLASH—The tops, branches and defective parts of trees left on the ground after a logging job.

STAND, FULLY STOCKED—A forest stand in which all growing space is effectively occupied, but having ample room for development of the crop trees.

SUGAR BUSH or SAP ORCHARD—Stand of maple trees used primarily for the production of maple sap.

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3. "Twelve Ways to Reduce Soil Erosion and Stream Pollution on Logging Roads", Sargent Goodhue, New Hampshire Division of Resources Development, Department of Resources and Economic Development, Concord, New Hampshire.

Protecting Your Forest Lands

1. "Forest Laws of New Hampshire" by John W. Barto, Esq. and Ernest J. Babcock, July, 1972, Society for the Protection of New Hampshire Forests, Concord, N.H.

2. "Forest Road Location and Erosion Control on Northern New Hampshire Soils" by Paul Winkelaar, Soil Scientist, White Mountain National Forest, Cooperative Extension Service, University of New Hampshire, Durham, N.H., Extension Publication No. 2.

3. "Information on Timber Harvesting Laws in New Hampshire", July, 1973, Ernest J. Babcock, prepared by Society for the Protection of New Hampshire Forests for the Division of Resources Development, Department of Resources and Economic Development and the University of New Hampshire Cooperative Extension Service.

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1. "New Hampshire Forest Market Report", Extension Circular No. 12, Cooperative Extension Service, University of New Hampshire and New Hampshire Department of Resources and Economic Development, (updated annually)

2. "Measuring Timber in Massachusetts – Simple Methods for Woodlot Owners," Cooperative Extension Service, College of Agriculture, University of Massachusetts, Amherst, Massachusetts.

3. "Measuring and Marketing Farm Timber," Farmers' Bulletin No. 1210, Slightly Revised March, 1958, United States Department of Agriculture, Washington, D.C.

This bulletin has been revised and shortened to help meet today's need for conserving paper.

Special Circular 206 Natural Resource Series

Forest Resources and Herbicides

A Guide to Control of Undesirable Woody Plants

The Pennsylvania State University, College of Agriculture, Extension Service, University Park, Pennsylvania

40

Prepared by R. D. Shipman, Professor of Forest Ecology, and E. P. Farrand, Associate Professor of Forest Resources Extension

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Contents

Why use herbicides? 1

Establishing new forests — timber and wildlife .. 2
- Treatment objectives
- Selecting the proper herbicide

Herbicides commonly used in Pennsylvania forests 3

Herbicide control methods in Pennsylvania 4-8

Recommendations for applying herbicides 9-12

Safety precautions 13

Cover Illustration:

Overstory hardwoods controlled with herbicides to release planted pines.

WARNINGS ON THE SAFE AND PROPER USE OF HERBICIDES

READ THE LABEL — before using herbicides, *always read all directions and follow them – exactly.* Notice warnings and cautions before opening the container. Repeat the process every time, no matter how often you use an herbicide. *Apply materials only on vegetation specified, in amounts suggested,* and *at times indicated* on the *latest manufacturer's label.* If an employee cannot read the language in which the product label is written, supervisors should make sure the employee understands the provisions of the label before any product is used.

STORE HERBICIDES WISELY — Keep herbicides out of reach of children, pets, irresponsible persons, and *livestock.* All herbicides should be stored under lock and key, outside the house, away from food, feed, seed, fertilizers, and other pesticides. *Always store* herbicides in their *original containers* and keep them tightly closed.

AVOID PHYSICAL CONTACT WITH HERBICIDES — Never smoke, eat, or chew tobacco while handling or applying herbicides. Protect your eyes from herbicides at all times. Avoid inhaling sprays or dusts. Do not spill herbicides on the skin or clothing. Wash hands and face and change to clean clothing after applying herbicides. *Do not use the mouth to siphon liquids* from containers *or to blow out* clogged *lines or nozzles. SEE YOUR DOCTOR IF SYMPTOMS OF ILLNESS OCCUR DURING OR AFTER THE USE OF HERBICIDES.*

KNOW YOUR POISON CONTROL CENTER PHONE NUMBER

41a

Forest Resources and Herbicides

A Guide to Control of Undesirable Woody Plants

WHY USE HERBICIDES?

Chemical control of unwanted vegetation is of concern to all Pennsylvanians — particularly to practicing forest and wildlife managers, tree farmers, lumber companies, livestock and poultry producers, and utility companies who maintain rights-of-way. Pasture lands, watersheds, highway roadsides, and recreational areas often require the proper and safe use of herbicides.

The chemical control of woody plants offers the land manager a more economical and effective method of managing undesirable vegetation than by laborious hand cutting or mechanical methods.

Since 1945, the well-known phenoxyacetic herbicides 2,4-D and 2,4,5-T have been successfully employed at every stage of forest management operations. Continuous advances in chemical formulation and application methods, as well as extension of knowledge about specific action and safety of various herbicides and the accumulation of years of practical experience, have helped to make herbicides a standard tool for the establishment and improvement of forest and wildlife habitats. Herbicides have played a leading role for weed control in tree and other woody-plant seedlings grown in nurseries; for field planting to mature trees; for conversion of unwanted brush to high-yielding plantations, old fields to pastures or low-quality cutover forests to vigorous new forests and improved wildlife habitats.

Deer browsing on low, woody growth in a small forest opening.

IMPROVING TIMBER QUALITY

Even with its large population, Pennsylvania is now more than 60 percent commercial forest land. In fact, it contains more forest acreage than any other state in the northeastern United States. However, the majority of

Pennsylvania's forest land is not producing timber of high quality. Only 44 percent of the nearly 17,000,000 acres is classified as sawtimber — the remaining 56 percent is in pole timber, saplings, and seedlings.

Perhaps the most significant feature of Pennsylvania's forest land is inadequate numbers of *desirable* high-quality trees. For example, only 5 percent of our forest land is in stands that have a desirable tree stocking of 40 percent or more. Desirable stockings include high-quality oaks, black cherry, sugar maple, and yellow poplar.

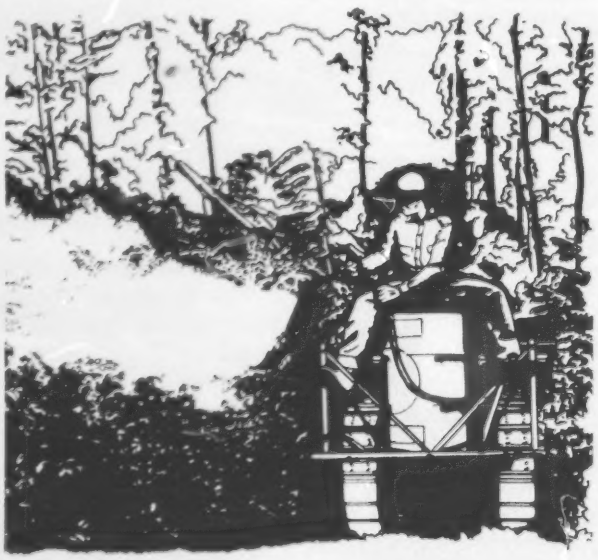
One method of bringing in a profitable return on the investment in these understocked stands is to encourage potentially desirable individuals by killing the cull and overmature trees with herbicides as a timber-stand-improvement operation. A Pennsylvania timber management study reported in 1960 that thinning operations with herbicides in hardwood-pole timber stands can produce more than one dollar's worth of additional timber for every dollar invested. When included as part of a management system, this operation would remove all cull trees 5 inches in diameter and larger, and one-half of the low-quality trees in each diameter class 5 inches and larger.[1/]

ESTABLISHING NEW FORESTS

Unlike coal, oil and minerals, trees are a renewable natural resource. As trees are harvested, the timber manager immediately has two fundamental choices open to him. He may (1) allow his forest to regenerate itself by natural means, or (2) restore his land to future timber production by planting or seeding.

In *either* case, good forest-management practices demand that he minimize competing weed species, thereby accelerating the growth of remaining trees on the site, and improve or change site conditions favorable to natural or artificial reforestation.

If the community of plants which develops after treatment includes a sufficient growth of desirable understory shrubs and herbaceous plants, then wildlife is also benefitted with an improved food and cover habitat.



Tractor mounted gun-type nozzle for high volume spray in hardwood.

WHAT ARE YOUR OBJECTIVES?

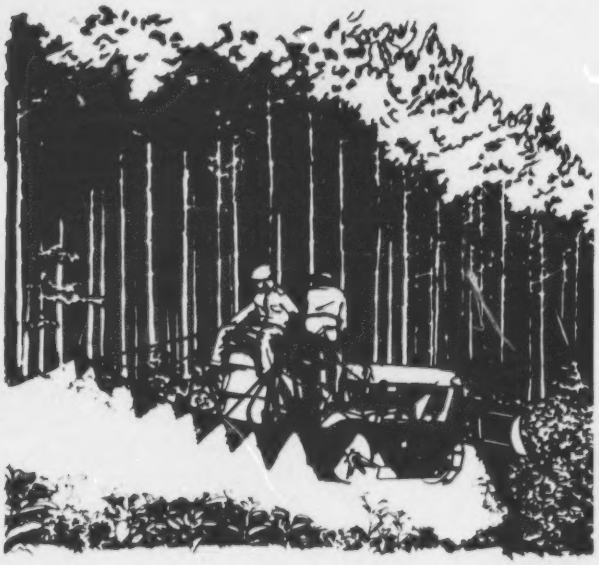
No single chemical or method of application is suitable for all forest or site conditions. Planning your program in advance of application will provide the most adequate control at the least cost per acre. One must assess a given site according to tree or brush size and number of stems to be treated, then choose the proper chemical and carrier, select the right method of application, and later accurately evaluate the results. The use of herbicides is recommended because they are economical, environmentally safe, effective, and versatile in application. These are the basic considerations in a successful program of chemical application in the manipulation of vegetation in forests, pastures, roadsides, and utility rights-of-way. Some chemical control methods applicable to improvement and establishment of forests in Pennsylvania are given in Table 1.

HERBICIDES

The chemical response, or level of vegetation control obtained *after* application, will vary according to tree or brush size and density, the kind of herbicide, the volume applied, carrier and active ingredient, season and method of application, species susceptibility, and equipment being used. It is imperative that the forest land managers, herbicide applicators, and particularly the crew foremen familiarize themselves with these factors *before* application. They can then select the most suitable method or methods for their particular set of stand conditions. Next: READ THE LABEL *again* before applying the herbicides to be sure the correct formulation has been chosen and applied through proper equipment at the right place, at the right time.

Herbicides most commonly used for establishment and improvement of forest stands are currently available under a variety of trade names. Many of these contain nearly the same chemical and concentration, but with varying amounts of inert ingredients and carriers. Therefore, it is better to become familiar with the common names of the chemicals themselves. A list of fourteen herbicides mentioned in this guide, according to their common and chemical names, is presented in Table 2. A brief description of those same herbicides which have proven most beneficial and effective in forest management activities in Pennsylvania follows.

[1/] Webster, Henry H. Timber Management Opportunities in Pennsylvania. U.S. Forest Service NE Forest Expt. Sta., Sta. Paper 137, 37 pp. 1960.



Tractor mounted boom sprayer for controlling low brush, vines, and weeds.

AMITROLE — also called amitrole-T; a white crystalline powder, or water soluble liquid, always mixed with water and applied as a foliage spray; inhibits chlorophyll formation and regrowth from buds; effective in the control of perennial broadleaf weeds and grasses, poison ivy, and Japanese honeysuckle.

AMS — ammonium sulfamate; a yellow crystalline solid that can be applied as a foliar spray in water solution or as dry crystals or concentrated solution to cut surfaces (frills notches or cups cut in the bark, or to freshly cut stumps).

BROMACIL — a white crystalline solid, formulated as a wettable powder to control a wide range of grasses and broadleaf weeds when sprayed on the soil surface; dry, granular, or pelleted formulations can be used for control of woody plants when applied on soil surfaces; a potent inhibitor of photosynthesis, similar in action to fenuron and fenuron TCA.

CACODYLIC ACID — also called dimethyl arsinic acid; a systemic herbicide, formulated as a liquid concentrate for tree injection work; will defoliate or desiccate a wide variety of plant species; used primarily for control of undesirable hardwoods and pre-commercial thinning of conifers; applied to trees with a specialized hatchet; rapidly inactivated on contact with soil particles.

DICAMBA — also called dichloro-o-anisic acid; the usual carrier is water, applied as a foliar spray or as granules for control of woody plants and brush; when used for the control of individual weed trees, a water solution is applied to spaced cuts at the tree base, using a specially calibrated tree injector.

FENURON — a substituted urea compound; used in forestry operations for control of undesirable woody plants; pellets are spread on the soil as basal, grid, or broadcast treatments; translocation is primarily upward in the xylem; most readily absorbed through the root system.

FENURON TCA — a non-selective herbicide used for temporary sterilization in non-crop areas, particularly in brush control; liquid formulations are diluted with water or oil and can be sprayed on foliage, as basal or ground application; granular formulations are applied to the soil in the same manner as fenuron pellets.

KARBUTILATE — primarily used for soil sterilization along railroads, highway shoulders, industrial sites, and in non-crop farm areas; formulated as a wettable powder and as granules; for control of hardwood and brush species where granules are placed on the soil as a broadcast or basal application.

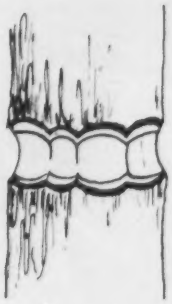
MSMA — also called monosodium methane arsonate; designed for crown kill of undesirable trees through spaced-cut injection methods employing a specialized hatchet; it is useful for the control of jack pine and red pine in the East, and for pre-commercial thinning of conifers in the West; MSMA appears to have a broader utility than cacodylic acid on most hardwood species, because of its greater residual killing action; data on optimum rates for many hardwood species in eastern forests is lacking.

PICLORAM — for use in controlling thick stands of brush and for certain hard-to-kill hardwood trees or conifers; pellets or beads can be broadcast evenly over an entire area as a non-selective application; for individual tree application, granules or pellets can be applied by hand or with a commercial granular applicator; pellets can be applied in a grid, row, or broadcast manner, similar to fenuron, fenuron TCA, and bromacil methods; picloram in liquid water soluble form may be applied as a foliage spray and to individual stems applied with all forms of tree injectors including the Hypo-Hatchet. Active through soil, stem, or foliage. Practical soil persistence is slightly less than fenuron but considerably longer than the phenoxy herbicides.

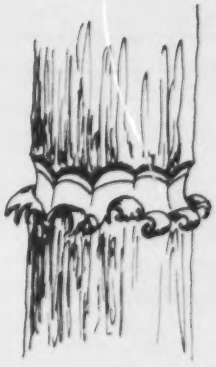
2,4-D; 2,4-DP; 2,4,5-T; 2,4,5-TP — also called the phenoxyacetic acids or phenoxys; this group includes the salts, esters, and amines of the chlorophenoxyacetic acids; the amines and salts are water soluble and applied by diluting with water; the emulsifiable preparation of the esters of 2,4-D or 2,4,5-T may be mixed with water or a petroleum solvent (oil carrier) before application; phenoxyacetic acids are usually applied in liquid form; they are considered truly selective in the control of woody vegetation, specifically when applied as a stump treatment, basal spray or with a tree injector; when applied to large areas of brush for site preparation in advance of planting or seeding, they are generally considered as non-selective herbicides. They may be used for conifer release when correct rate, volume, and timing are used.

HOW AND WHEN TO APPLY

A) CUT-SURFACE TREATMENTS: FOREST TREES



1) GIRDLE-Used for killing trees, generally 12 inches and above in diameter. No chemical is added. Girdling involves the removal of a 3- to 5-inch-wide band of bark completely around the trunk with single overlapping axe or hatchet cuts. Bark and phloem must be completely severed to disrupt the flow of nutrients to the roots. Sprouting below the girdle may occur; girdling is hard work, time consuming, and costly. Girdling was the first method used for eliminating undesirable trees. This is an acceptable method if sprouting is to be produced for wildlife browse or if sprouts do not interfere with tree seedlings, natural or planted. Girdling is done more easily in spring, when bark separates easily from wood.



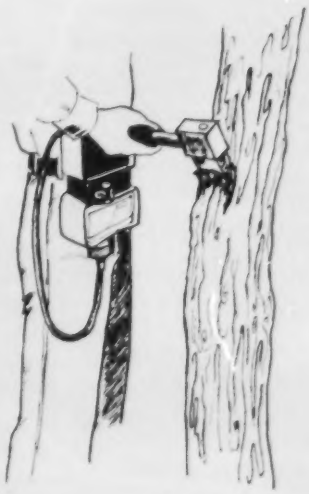
2) FRILL GIRDLE (continuous cuts)-Used for killing trees 5 inches in diameter and larger. A single line of overlapping downward axe or hatchet cuts is made completely around the trunk. Do not remove chips. Use an oil can with spout or a squeeze bottle, pouring chemical into "frills" completely around the tree. Frills made 4½ feet above ground are convenient, but on species that are hard to kill, such as hickories, persimmon, and gums, the cuts should be made around the tree near the ground. Some chemicals, such as picloram, which moves both up and down in the tree, are less sensitive to height of cut, but all are affected to some degree. Trees can be killed in any season with this method, but late spring, summer, and fall are best. This method does not work well on species such as maples during the spring, when heavy sap flow may wash the chemical from the frill.

3) FRILL GIRDLE (spaced cuts)-Cuts are made at a convenient height with an axe, spaced 2 inches apart edge-to-edge. The chemical can be applied diluted or undiluted, 1 milliliter (1 cubic centimeter) in each axe cut. If undiluted formulations are used, cuts can be spaced 3 to 4 inches edge-to-edge. Effectiveness will vary with concentration and spacing of cuts. This treatment is effective in any season, but May to August (growing season) is best. On difficult-to-kill species, place cuts closer together and use undiluted formulations.

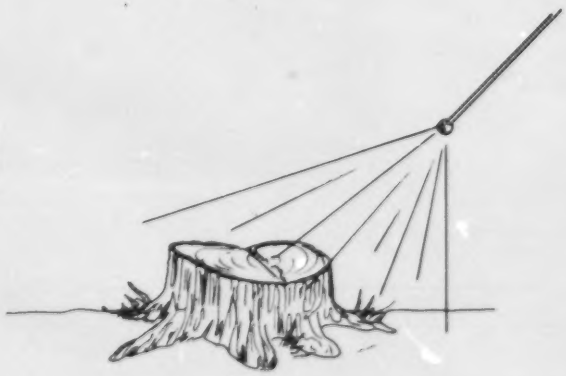
4) FRILL WITH NOTCHES-Notches or "cups" are made with an axe at the base of the tree, spaced 1 cut per each 2 inches of tree diameter, or 4 to 6 inches apart around circumference on larger trees. Two downward axe cuts, one above the other, are made, and the chip is pried out. To each "cup" apply 1 tablespoon of dry, crystalline ammonium sulfamate. This chemical is corrosive to metal and, while non-toxic, may cause skin irritation under prolonged contact. Use plastic spoons and non-metal container when applying. Ammonium sulfamate is a good root translocator and is very effective on hard-to-kill species and prolific sprouters. Generally, treatments can be made at any season, but the growing season is best.

5) INJECTOR (spaced cuts)-Use a special tree injector calibrated to deliver ½ to 1 ml of herbicide per cut upon impact, through the bark and into wood at base of the tree. Space the cuts 2 inches apart, or, if a difficult-to-kill species, cuts can be continuous. Undiluted formulations with wider spaced cuts are also effective. Can be used on all species, particularly 2- to 3-inch diameter trees, at any time of year, but May to August treatments are most effective.

6) HYPO-HATCHET (spaced cuts)-Apply incisions waist-high with a specialized hatchet-type tree injector. Apply 1.5 ml per cut depending upon species and season. Most effective on soft-textured conifers, jack, red and white pines of all tree sizes. Useful in pre-commercial thinning of coniferous trees 8 inches in diameter and below. Effective on eastern hardwoods, especially beech, red maple and sugar maple. On hardwoods 8 to 16 inches in diameter, make cuts 3 to 6 inches apart around circumference during any season, but summer and fall are best with spaced incisions. Besides arsenicals, other chemicals such as 2,4-D and picloram can be applied with the Hypo-Hatchet.



7) STUMP TREATMENT-As soon as possible after cutting, spray or paint the flat stump surface with herbicide. Make sure that spray reaches the cambium and runs down sides to the root collar. Trees that are smaller than 4 inches in diameter can be "V-notched" with an axe and crystalline ammonium sulfamate placed in the notch with a spoon. This treatment is very effective on species such as oaks, maples, beech, and hickories that sprout profusely. However, expect poor root sucker control of black locust, sassafras, and sumac. A spray or dry crystals can be applied at any season, but as soon as possible after cutting.



B) BARK, FOLIAGE AND SOIL TREATMENTS: BRUSH AND FOREST TREES

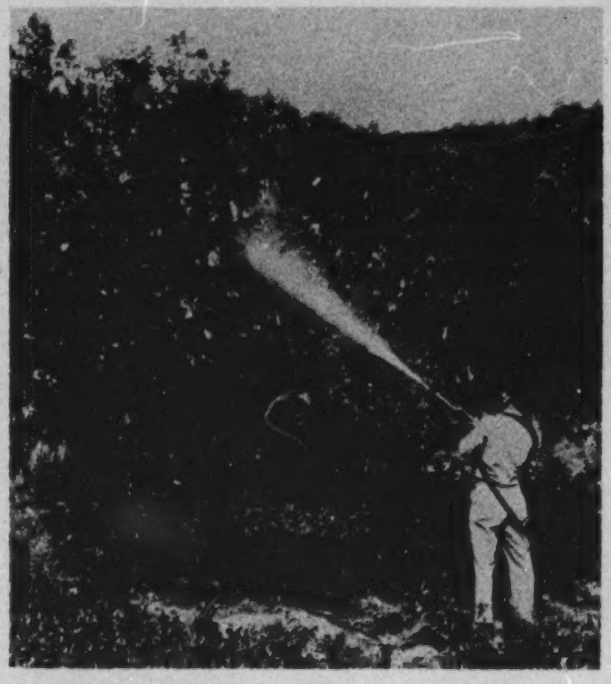
Knapsack sprayer for basal spray of hardwood brush.

1) BASAL BARK—This method is most useful on stems less than 2 inches in diameter, on scattered brush or "clumps" of hardwood brush and small trees. Drench lower 12 to 15 inches of plant stem to the point of runoff, using a solid-cone spray. Often used on species resistant to a foliage spray. Spraying can be done at any season, but dormant season basal stem applications, particularly on utility rights-of-way, are very effective. Expect poor control on root suckering species such as black locust, hickories, and sassafras. Scattered clumps of hardwood brush in pastures and old fields are prime situations for use of basal bark sprays; most effective on thin-barked species. Crankcase oil or diesel oil can be used as a diluent.

Mist blower mounted on D-2 tractor.

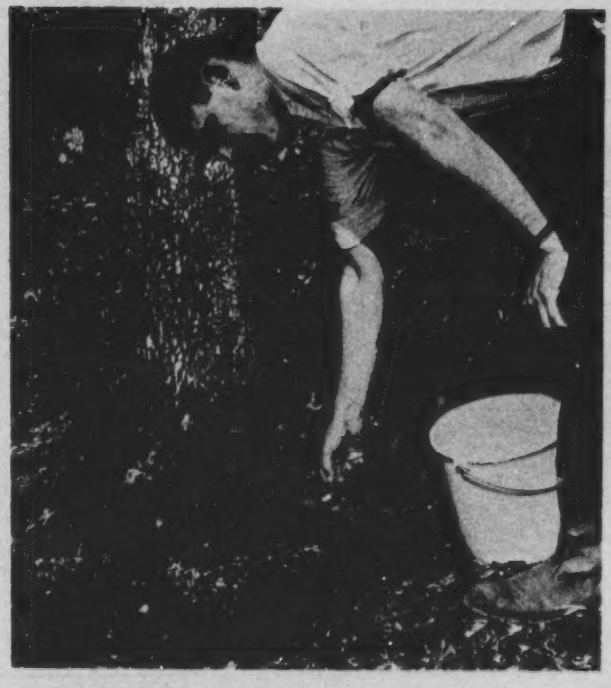
2) FOLIAGE SPRAY (low volume)—Under good growing conditions a water carrier is most often used with this method. Large tracts of mixed brush and hardwoods growing on utility rights-of-way can be done economically. On areas where low-volume ground sprayers or powered mistblowers cannot be used, small aircraft or helicopters can be employed effectively. Very sparse brush is not ideally suited for this method since the chemical which does not reach the plant is wasted. A drift control agent is often added to the spray mixture. Best results will be obtained from sprays applied during periods of optimum growth after full leaf development. In low-volume ground spraying the objective is to obtain uniform distribution over the brush, rather than drenching of the foliage. Aerial spraying is best done by experienced custom applicators, requiring skilled pilots and highly specialized equipment.

3) FOLIAGE SPRAY (high volume)—High-volume foliage applications call for thorough wetting of leaves, stems, and shoots. Size of the brush has a direct relationship to the volume of spray used, since complete wetting of all plant parts is the objective. Water is the preferred carrier with this method; however, under conditions of unfavorable growth, use of oil-water carriers gives a better top kill. For treating brush that is accessible (less dense) to power equipment, this method is most economical. Most high-volume sprays are applied with ground equipment such as truck- or tractor-mounted tank equipment. As with low-volume sprays, late spring and summer, or from time foliage is fully developed, is the optimum time for best results.



Foliage spray to control hardwood brush and small trees.

4) SOIL APPLICATION (dry materials)—Dry, non-liquid herbicides are manufactured as pellets, granules, beads, and wettable powders. Applications to the soil surface may be made at any time, but late winter and early spring applications are most effective. They are not recommended for use in marshy areas or standing water. Do not apply to frozen ground. Apply to individual trees or "clumps" of brush on all species and sizes. Depending upon kind of tree or brush, apply as basal (spot), grid, row, or broadcast methods. Effectiveness of control will vary most with soil type and species. Basal or "spot" treatment is recommended for use in pastures and rangelands. Soil applications have been used successfully for release of underplanted seedlings, as a spot follow-up on utility rights-of-way, in pasture and range development, and for selective control of roadside woody plants. Do not apply within root zone of desirable plants.



Pelleted herbicide being applied around base of unwanted tree.

Table 1. Some chemical control methods and their use in Pennsylvania forests.

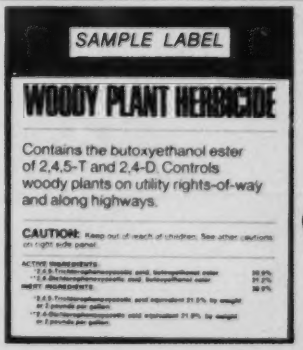
SILVICULTURAL OBJECTIVE	*HERBICIDE OBJECTIVE*	*TREATMENT METHODS AVAILABLE* [2]
TIMBER STAND IMPROVEMENT (TSI)	To improve growth of desirable residual trees and create growing space for tree reproduction.	Girdle, frill girdle, frill with cups, tree injection, hatchet injection, basal bark, and soil application.
RELEASE OF CONIFERS	*Low release*: from overtopping vegetation (competitors are low shrubs about same height as conifers, or slightly taller).	Foliage spray (low volume) applied with aircraft or powered mistblower, basal bark, and stump treatments.
	High release: from saplings or high understory (competitors are tall brush and low-value hardwoods taller and completely overtopping the conifers).	Foliage spray (low volume) applied with aircraft or powered mistblower, basal bark, frill girdle, frill with cups, stump treatment, tree injection, and soil application.
PLANTING – SITE PREPARATION	To control or set back competing vegetation before planting or seeding; sometimes called pre-planting release.	Foliage spray applied with aircraft, mistblowers, backpack, or ground power pumps.
PRE-COMMERCIAL THINNING	To control stand density by chemical thinning of dense thickets of coniferous, hardwood or mixed stands that have not reached merchantable size.	Basal bark, tree injection, hatchet injection, and soil application.
STAND CONVERSION	To remove existing low-value hardwoods to favor desirable timber species; to increase browse value and create openings for wildlife.	Girdle, tree injection, soil application, and aerial application.

[2] See Tables 2 and 3 for chemicals used and treatment explanation.

Table 2. Common and chemical names of herbicides mentioned in this guide[3].

COMMON NAME OR DESIGNATION	*CHEMICAL NAME*
amitrole	3-amino-s-triazole
AMS	ammonium sulfamate
bromacil	5-bromo-3-sec-butyl-6-methyluracil
cacodylic acid	hydroxydimethylarsine oxide
dicamba	3,6-dichloro-o-anisic acid
fenuron	1,1-dimethly-3-phenylurea
fenuron-TCA	1,1-dimethly-3-phenylurea mono (trichloroacetate)
karbutilate	tert-butylcarbamic acid ester with 3-(m-hydroxyphenyl)-1,1-dimethylurea
MSMA	monosodium methane arsonate
picloram	4-amino-3,4,5-trichloropicolinic acid
2,4-D	(2,4-dichlorophenoxy) acetic acid
2,4-DP (dichlorprop)	2-(2,4-dichlorophenoxy) propionic acid
2,4,5-T	(2,4,5-trichlorophenoxy) acetic acid
2,4,5-TP (silvex)	2(2,4,5-trichlorophenoxy) propionic acid

[3] Weed Science Society of America, 1974 designation.


SAMPLE LABEL

WOODY PLANT HERBICIDE

Contains the butoxyethanol ester of 2,4,5-T and 2,4-D. Controls woody plants on utility rights-of-way and along highways.

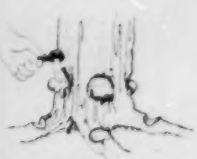
CAUTION: Keep out of reach of children. See other cautions on right side panel.

ACTIVE INGREDIENTS:
*2,4,5-Trichlorophenoxyacetic acid, butoxyethanol ester 33.0%
**2,4-Dichlorophenoxyacetic acid, butoxyethanol ester 31.2%
INERT INGREDIENTS 35.8%

*2,4,5-Trichlorophenoxyacetic acid equivalent 21.0% by weight or 2 pounds per gallon.
**2,4-Dichlorophenoxyacetic acid equivalent 21.0% by weight or 2 pounds per gallon.

Table 3. General recommendations for applying herbicides to forest trees, brush, and woody vines in Pennsylvania

A) CUT-SURFACE TREATMENTS: FOREST TREES

APPLICATION TECHNIQUE	TARGET SPECIES	WHEN TO APPLY	HERBICIDE AND RATE (lb. ae or ai)	HOW TO APPLY
1) *GIRDLE*	Trees 12" in diameter and larger	Spring, April through June, when bark is loose.	None	Remove 3- to 5-inch-wide ring of bark and phloem completely around trunk. Can use axe, Power Girdler, or Brady Tree Girdler. Tree death is slow (2-5 yrs.); shoots arise below girdle and remain alive; hard work, time consuming and costly.
2) *FRILL GIRDLE (continuous cuts)*	Trees 5" to 6" in diameter and larger.	Any season, but spring and growing season treatments are most effective.	(1) 2,4-D and/or 2,4,5-T* (ester) 16 lbs/100 gal oil. (2) ammonium sulfamate (AMS) 8 lb/2 gal water. (3) picloram + 2,4-D (amine 2.54 lb/gal) diluted 1 to 1 with water for hard or sugar maple.	Apply herbicide to overflowing in single line of overlapping downward axe cuts completely around trunk. Frills made waist high above ground level are most convenient. An oil soluble red stain added to solution will indicate treated trees. Do not remove chips made by axe.
FRILL GIRDLE (spaced cuts)	Trees 5" in diameter and larger.	Any season, but spring and growing season treatments are most effective.	(1) 2,4-D and/or 2,4,5-T* (amine) 1 ml per cut from 4 lb/gal. (2) picloram + 2,4-D (amine) 1 ml per cut from 2.54 lb/gal; or 50/50 dilution with water. (3) dicamba 1 ml per cut from 4 lb/gal diluted 1 to 1 with water.	Apply 1 ml in each axe cut about waist high around tree, spaced 2" edge to edge. 2,4-D and/or 2,4,5-T more effective May to August on all species. Picloram + 2,4-D or dicamba effective any time on most species. DO NOT ALLOW HERBICIDES TO CONTAMINATE WATER USED FOR IRRIGATION OR OTHER DOMESTIC PURPOSES. DO NOT APPLY PICLORAM OR DICAMBA IN THE ROOT ZONE OF DESIRABLE VERY SUSCEPTIBLE SPECIES SUCH AS YELLOW POPLAR, BASSWOOD, OR WHITE PINE.
4) *FRILL WITH NOTCHES* 	Trees 5" in diameter and larger.	Any season.	ammonium sulfamate (AMS) dry crystals 1 tablespoon per notch (95% active).	Dry crystals placed directly in notches or "cups" around base of tree, spaced 4" to 6" apart or 1 per 2" tree diameter. Two downward axe cuts, one above the other, prying out the chip.

NOTE: *2,4,5-T is *not* to be used on food crops, around homes, recreation areas, pond or ditch sites. Registered use of 2,4,5-T is for control of weed trees and brush on range, pasture and forest or rights-of-way and other non-crop land.

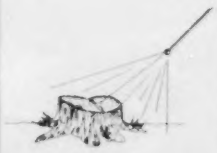
DEFINITIONS:

ae (acid equivalent) — The amount of active ingredient present in a certain herbicide formulation expressed in terms of the parent acid. The label will give pounds of acid per gallon or the percent of formulation which is active. Example: 2,4-D expressed as "4 pounds of acid equivalent per gallon."

ai (active ingredient) — That portion of the formulation that is responsible for the herbicidal activity. The remainder of the formulation given on the label will be carrier, emulsifier or other non-active ingredients. Example: 2,4,5-T expressed as "8 pounds active ingredient in 50 gallons of water per acre."

Table 3, continued:

A) CUT-SURFACE TREATMENTS: FOREST TREES

APPLICATION TECHNIQUE	TARGET SPECIES	WHEN TO APPLY	HERBICIDE AND RATE (lb. ae or ai)	HOW TO APPLY
5) *INJECTOR (spaced cuts)*	Trees 5" in diameter and larger.	Most effective May to August on all species.	(1) 2,4-D and/or 2,4,5-T* (amine) 1 ml per cut from 4 lb/gal. (2) picloram + 2,4-D (amine) 1 ml per cut from 2.54 lb/gal; dicamba 1 ml from 4 lb/gal diluted 1 to 1 with water. (3) 2,4-D + 2,4,5-T (ester) 40 lb/100 gal oil.	Use a special tree injector calibrated to deliver 1 ml per cut, space cuts 2" apart (edge-to-edge) at base of tree. DO NOT ALLOW HERBICIDES TO CONTAMINATE WATER USED FOR IRRIGATION OR OTHER DOMESTIC PURPOSES. Apply to overflowing in overlapping cuts made with special tree injector. Use on all species any time of year.
6) *HYPO-HATCHET (spaced cuts)*	Trees below 8" in diameter. Hardwoods 8" to 16" in diameter require 1 cut per inch of diameter during all seasons. Effective on beech, red maple and hard maple.	Most effective in summer and fall with spaced injections.	Monosodium methane arsonate; or cacodylic acid 1.3 ml per cut depending upon species and season.	Apply cuts waist high with specialized hatchet-type injector. Useful in precommercial thinning on jack, red, and white pines. WEAR GOGGLES. ACCIDENTAL SPILLAGE ON THE SKIN SHOULD BE REMOVED WITH WATER IMMEDIATELY.
7) *STUMP* 	Sprout control on hardwood cut stumps, particularly on species that sprout profusely, oaks, maple, beech, hickories. Root sucker control of black locust, sassafras and sumac will be improved by use of a formulation containing picloram.	Any season, but most effective as soon as possible after cutting.	(1) 2,4-D and/or 2,4,5-T* (amine) 16 lbs/100 gal. Apply with low volume knapsack sprayer using solid cone nozzle of medium orifice. (2) ammonium sulfamate (AMS) dry crystals 1 oz. per inch of stump diameter in V-notches. (3) Picloram + 2,4-D (amine) 2.54 lb/gal).	Paint or spray flat stump surface with herbicide, making sure that spray runs down sides to root collar. Trees smaller than 4" in diameter can be V-notched with an axe and crystalline ammonium sulfamate (AMS) sprinkled into notch.

NOTE: *2,4,5-T is *not* to be used on food crops, around homes, recreation areas, pond or ditch sites. Registered use of 2,4,5-T is for control of weed trees and brush on range, pasture and forest or rights-of-way and other non-crop land.

DEFINITIONS:

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ai (active ingredient) — That portion of the formulation that is responsible for the herbicidal activity. The remainder of the formulation given on the label will be carrier, emulsifier or other non-active ingredients. Example: 2,4,5-T expressed as "8 pounds active ingredient in 50 gallons of water per acre."

Table 3, continued:

B) BARK, FOLIAGE, AND SOIL TREATMENTS: BRUSH AND FOREST TREES

APPLICATION TECHNIQUE	TARGET SPECIES	WHEN TO APPLY	HERBICIDE AND RATE (lb. ae or ai)	HOW TO APPLY
1) *BASAL BARK*	Scattered brush or "clumps" of hardwood brush and small trees. Can be used on species resistant to a first foliage spray. Expect poor control on root suckering species, black locust, hickories, and sassafras	Any season	(1) 2,4-D + 2,4,5-T; 2,4,5-T*; 2,4-D + 2,4-DP, 12-24 lb/100 gal oil (low volatile esters) (2) picloram + 2,4,5-T 3 gal/100 gal oil or dicamba 3 lb + 2,4,5-T 12 lb/100 gal oil (Use oil soluble formulation).	Drench lower 12" to 15" of plant. Density of brush will determine rate/A Drench lower 12" to 15" of plant DO NOT APPLY NEAR DESIRABLE PLANTS OR ALLOW CONTAMINATION OF WATER USED FOR IRRIGATION OR DOMESTIC PURPOSES.
2) *FOLIAGE SPRAY (low volume)*	Large tracts of mixed brush and hardwoods growing on utility lines and rights-of-way. Adaptable for conifer release on forest lands and for range and pasture establishment. Site preparation in advance of seeding or planting forest trees. Trees less than 20' tall with mist blower.	All hardwood species during late spring and summer. Apply during growing season.	(1) 2,4-D + 2,4,5-T, 2 to 4 lb in 5 to 10 gal water/A. (2) picloram + 2,4,5-T, 5 lb/A (ester), 1 to 3 gals + 97 to 99 gals petroleum solvent.	Use aerial application, low volume sprayer or powered mist/blower at 1/4 to 1/3 throttle for best coverage. Good root collar coverage is essential. Use drift control agent in mixture. DO NOT APPLY WITHIN ROOT ZONE OF DESIRABLE PLANTS OR ALLOW HERBICIDE TO CONTAMINATE WATER USED FOR IRRIGATION OR DOMESTIC PURPOSES.
3) *FOLIAGE SPRAY (high volume)*	Scattered brush or "clumps" of hardwood brush. Can be used on species not controlled by prior sprays such as maple, oak, ash and persimmon, growing along fence rows, highways and rights-of-way and other non-crop areas.	Late spring and summer from time foliage is fully developed. Dormant season ineffective.	(1) 2,4-D + 2,4,5-T at 8 to 24 lbs/A applied in 10 to 30 gals per/A volume. (2) 2,4,5-T* at 4 lb/A + 2 gals of formulation containing (picloram + 2,4-D) as amine salts from 2.54 lb/gal applied in 10 to 30 gals/A volume. (3) picloram + 2,4-D 1 to 4 gals in 10 to 25 gals/A volume. (4) dicamba 1.25 lb + 2,4-D or 2,4,5-T 2.5 lb/100 gals in water.	Apply uniformly over top of brush as a coarse spray. Use on all species during June and July. Ash is resistant to all listed herbicides. DO NOT APPLY WITHIN ROOT ZONE OF DESIRABLE PLANTS OR ALLOW ANY OF THESE HERBICIDES TO CONTAMINATE WATER USED FOR IRRIGATION OR OTHER DOMESTIC PURPOSES.
4) *SOIL APPLICATION (dry materials)*	Individual trees or "clumps" of brush of all species and sizes. For release of underplanted trees (stand conversion), follow-up on sprayed rights-of-way, pasture development and selective control of roadside woody plants.	Apply on all species during any season, but late winter and early spring applications are most effective.	*Individual trees:* Place 25% fenuron or 22% fenuron-TCA completely around base of tree 1 to 2 teaspoons/inch tree diameter; place 10% picloram completely around base of tree 1 teaspoon/inch tree diameter; place 10% bromacil pellets completely around base of tree 2 teaspoons/inch tree diameter. *Clumps of brush:* Apply fenuron broadcast or grid pattern 4 to 8 lb/A; or 10% picloram 2 to 8 lb/A; or karbutilate 12 to 16 lb/A.	Apply as pellets, granules, or beads. For release of underplanted trees use grid or row methods; for non-selective control, apply broadcast by hand or cyclone seeder. Overstory oaks most susceptible to fenuron, understory witch hazel, sassafras and ironwood are most susceptible to picloram. DO NOT APPLY IN ROOT ZONE OF DESIRABLE PLANTS.

NOTE: *2,4,5-T is *not* to be used on food crops, around homes, recreation areas, pond or ditch sites. Registered use of 2,4,5-T is for control of weed trees and brush on range, pasture and forest or rights-of-way and other non-crop land.

DEFINITIONS:

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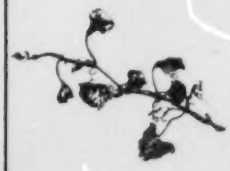
ai (active ingredient) — That portion of the formulation that is responsible for the herbicidal activity. The remainder of the formulation given on the label will be carrier, emulsifier or other non-active ingredients. Example: 2,4,5-T expressed as "8 pounds active ingredient in 50 gallons of water per acre."

Table 3, continued:

C) PLANTING SITE PREPARATION: NONSELECTIVE CONTROL

APPLICATION TECHNIQUE	TARGET SPECIES	WHEN TO APPLY	HERBICIDE AND RATE (lb. *ae* or ai)	HOW TO APPLY
1) *FOLIAGE SPRAY on all woody species in future planting site*	All unwanted small trees, shrubs and brush in advance of planting or seeding.	Late spring, summer and early fall.	(1) 2,4-D + 2,4,5-T at 4 to 8 lb/A in water 10 to 30 gals/A total volume. (2) 2,4,5-T* at 4 to 12 lb/A in water 10 to 30 gals/A total volume. (3) 2,4,5-T at 4 lb/A + 2 gals of a formulation containing (picloram + 2,4-D) at 2.54 lb/gal (amine) applied in water at 10 to 30 gals/A of total volume. (4) 2,4-D + 2,4-DP at 2 lbs of each plus 1 qt of MSMA (Transvert) in a total of 10 gals volume/A. (5) 2,4,5-T at 2 to 4 lbs plus 1 to 2 pts Transvert in 9 to 15 gals of water.	Apply aerially or from ground or tractor-mounted sprayer in June, July or August. If permitted, burn in winter to eliminate dead debris. Note: Conifers should not be planted on sites sprayed with picloram any sooner than 6 months following application.

D) WOODY VINES

1) *POISON IVY*	Climbing or procumbent vines.	Late spring applications most effective. During dormant season saturate stems with 5% 2,4,5-T in oil carrier.	(1) Foliage spray, amitrole (50%) 1 lb in 25 gals of water. (2) 2,4,5-T* (1/2%) in water. (3) ammonium sulfamate (95%) 1 lb /gal of water. (4) picloram + 2,4-D at 1 gal in water to make 100 gals, applied as a full coverage spray or 3 gal/A in low volume spray. (5) picloram pellets (10% ai) at 4 to 6 lbs ae/A broadcast over root zone.	Thoroughly wet all plant surfaces and woody stems using knapsack-type garden sprayer. Spot treat regrowth as required. Note: Use picloram *only* where desirable trees with root zone in the treatment area are expendable.
2) *JAPANESE HONEYSUCKLE*	Climbing or procumbent vines.	Foliage spray in late spring or summer. Control during dormant season is difficult.	(1) Foliage spray, amitrole (50%) 2 lbs in 25 gals water. (2) 2,4-D or 2,4-D + 2,4,5-T 2 to 3 lbs/100 gal water. (3) picloram 3 lbs/A in water.	Apply as foliage spray, thoroughly wetting all foliage and stems. Density of cover will determine volume of spray per acre. Spot treat regrowth as required. Generally requires a follow-up or second application. Do *not* use picloram where root zone of desirable trees extend into treated area.
3) *GRAPE VINES* 	Grape tangles and large climbing vines.	Foliage spray in June or July. During dormant season use basal spray.	*Grape tangles:* Foliage spray with 2,4,5-T* 4 lb/100 gal in water. In dormant season, basal spray with 2,4,5-T* 16 lb/100 gal oil. *Large climbing vines:* Basal spray with 2,4,5-T* 16 lb/100 gal oil.	Apply as foliage or basal spray depending on herbicide and season.

NOTE: *2,4,5-T is *not* to be used on food crops, around homes, recreation areas, pond or ditch sites. Registered use of 2,4,5-T is for control of weed trees and brush on range, pasture and forest or rights-of-way and other non-crop land.

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52-A

HERBICIDES IN FORESTRY

By

Kenneth F. Lancaster
Field Representative
USDA-Forest Service,
S&PF

Introduction

Herbicides have gained wide use in forestry because they have proven to be one of the most effective and most economical means of carrying out control measures from site preparation to the removal of undesirable trees.

Preventing competing vegetation from impairing the growth of trees is the most important factor in hardwood plantation establishment and in Christmas tree culture. Chemical site preparation, either before or after planting, can be effectively used in place of mechanical methods.

Timber Stand Improvement (TSI) is one of the first essential steps toward rehabilitating most of our young second growth stands on the better sites. Despite improved markets for cull material and small trees, TSI remains as one of the major needs of the private woodlot.

Herbicides have been used more widely in TSI than in any other forestry work and have proven to be the most efficient way of doing the job. But, if chemical costs continue to climb, the financial advantage of herbicidal use over mechanical means can disappear.

I. SITE PREPARATION

Chemical site preparation is the elimination of grass and weed competition for planting of softwood and hardwood seedlings for timber production or for growing Christmas trees. On many planting sites it includes the elimination of brush competition also.

1. Grass and weed competition (sod) elimination -- Simazine (Princep 80W) is one of the most useful and reliable herbicides used in forestry. A pre-emergent chemical absorbed through the roots, kills by its adverse effect on photosynthesis. Simazine may be applied at any time of the year without shielding the tree seedlings. It is most effective in preventing new weed growth and should be applied to weed-free surfaces in early spring before weed growth has begun.

   Paraquat, amitrole, 2, 4D and dalapon may be used in the control of established weeds. But, use of these herbicides necessitates the shielding of the young tree to avoid damage.

   Simazine should not be applied to hybrid poplars as they are susceptible to damage. It should be used with caution on hard maple, white ash, basswood, black cherry and black locust as they are easily damaged by this chemical. As a rule, apply about 3 pounds per acre of active Simazine in planting hard maple, white ash, black cherry and balsam fir. For basswood and silver maple increase the rate to 4 pounds. Black walnut and the oaks can withstand a heavier application (Refer to label).

Spray Mixing* - A method of mixing and applying simazine which is applicable for the average person treating a small number of trees with limited equipment, Table 1 has been prepared and should be used in the following sequence:

a. Determine the rate of application in pounds of active simazine per acre for the species and soil type to be sprayed.

b. From Table 1, using the application rate selected above, choose the desired spot size, column (2).

c. Calibrate your sprayer and nozzle using one gallon of clean water by spraying test spots of the desired size. The length of the spray burst, approximately 2 seconds, will determine the number of spots that one gallon will cover.

d. Using Table 1 for the desired application rate - column (1), spot size column (2), and number of spots treated per gallon - column (4), select the ounces of active ingredient to be mixed per gallon of water.

e. Where the active simazine is supplied in the form of Princep 80W, convenient conversion factors for measuring this material by weight, fluid ounces or tablespoons are in columns (6) and (7) respectively.

f. Make a slurry or paste from the wetable powder to mix with water in the spray tank.

* Taken from: "The Planting of Hardwood Trees & Shrubs," Ontario Ministry of Natural Resources, Toronto, Ont.

TABLE 1. Spray Mixing Rates for Simazine

Princep 80W

(1) Pounds / Acre (active)	(2) Spot Dimention (inches)	(3) Spot Size (sq.ft.)	(4) Spots/ Gallon	(5) Ounces / Gallon (active)	(6) Ounces / Gallon (weight)	(7) Tablespoons / Gallon (U.S.Stand.)
3	20	3	300	1.00	1.25	6.25
			250	0.83	1.04	5.20
			200	0.67	0.84	4.20
3	24	4	250	1.10	1.38	6.90
			200	0.88	1.10	5.50
			150	0.66	0.83	4.10
3	36	9	200	1.98	2.48	12.40
			150	1.49	1.86	9.30
			100	0.99	1.24	6.20
4	20	3	300	1.32	1.65	8.25
			250	1.10	1.38	6.90
			200	0.88	1.10	5.50
4	24	4	250	1.47	1.84	9.20
			200	1.18	1.48	7.40
			150	0.88	1.10	5.50
4	36	9	200	2.64	3.30	16.50
			150	1.98	2.47	12.35
			100	1.32	1.65	8.25
5	20	3	300	1.65	2.05	10.30
			250	1.38	1.72	8.60
			200	1.10	1.38	6.90
5	24	4	250	1.83	2.29	11.40
			200	1.47	1.84	9.20
			150	1.10	1.38	6.90
5	36	9	200	3.31	4.14	20.70
			150	2.48	3.10	15.50
			100	1.65	2.06	10.30

Note: Conversion Factors -

1 oz. Princep = 5 tablespoons approx.
3.25 oz. Princep = 1 cup

1 cup = 8 fluid ounces
1 cup = 16 tablespoons
1 tablespoon = 3 teaspoons

Other Herbicides for Weed Control:

Amitrole - (amino-triazole) is a systemic herbicide, used in the spring after the new vegetation has reached four inches in height, can be readily absorbed by foliage and roots. It destroys chlorophyll in the plant and its effect is first noticed by a whitening of the foliage. Obtainable as a powder or liquid, it is usually used in liquid form and applied before or after trees are planted. Herbicidal effect usually takes one week to show up. Amitrole may persist in the soil for several weeks depending on weather conditions. Sold as TM-Amitrol-T or Cytrol.

Atrazine - Another triazine, is similar in form and action to simazine except that it is much more soluble, moves more readily in soil, can be absorbed through foliage and therefore can injure evergreens. Herbicidal activity of atrazine is faster than simazine and does not last as long. Primarily used as 80% wettable powder (80W) and used mostly in Christmas tree management in combination with simazine. Most common rate of application is 2 lbs. of actual herbicide per acre - 2 1/2 lbs of 80W per acre. Sold as Atrex.

Amazine - Amazine is a combination of simazine and amitrole effective in control of herbaceous vegetation and has to be used as a directed spray.

Paraquat - A contact herbicide which rapidly kills all green foliage. Ordinarily it is not translocated within the plant and has little affect on the root system. When used in combination with the triazines it may be translocated and a more lasting effect produced. Paraquat is absorbed by clay and does not leach through the profile or move with surface erosion. This material is both toxic and corrosive and all cautions on label should be observed. Usable rate of application is 2 qts/acre. Use of a non-ionic surfactant (wetting agent) in spray solution improves effectiveness. Use all caution. It's dangerous! Sold as Paraquat CL.

2. Removal of Hardwood Brush in Site Preparation

   a. Basal Bark Treatment on stems less than 3 to 4 inches in diameter use 2,4-D and 2,4,5-T low volatile esters (LV) or oil soluble amine. On hard-to-kill species, use 2,4,5-T low volatile esters. Mix at label rate with oil carrier.

      In application, drench the entire surface or lower 12-18 inches of trunk and root collar to a point of runoff so that dormant buds at ground level are killed. A dye color such as vermilion red oil can be used to identify treated surfaces.

   b. Mist blower application is less expensive than basal treatment. Use mixtures containing 2,4-D and 2,4,5-T (often referred to as brushkillers). They are more effective than 2,4-D alone in controlling many hardwood species, particularly the aspens and maples. The application rate listed on the label will give good control of most species, even the relatively hard-to-kill species.

      Purchase only the low volatile ester formulations, since these are less likely to vaporize and cause damage outside the spray area. Some trade names are: Weedone Brushkiller 2:1; Esteron 3-3E; Chipman Brushkiller 96.

Application Methods - Apply at the rate specified on the label using the techniques described below (Boynton et. al). Avoid close range application to crop trees.

Timing: For best results apply after full leaf development when brush is growing vigorously. Do not apply during or immediately after extended periods of dry weather. In Christmas tree stands, apply only after the beginning of August when new growth of conifers has hardened off.

Application Technique: To get complete coverage without wasted effort, the area should be treated systematically by blocks or strips. Because mist blowers use lower volumes of spray, it is often impossible to see any spray deposit on the foliage. Thus, it is essential to mark out clearly defined units before starting to spray.

If the area is already divided into blocks by trails, or other boundaries, it may be convenient to treat one block at a time. If the blocks are small enough, no further division will be required. Larger blocks should be divided into parallel strips generally no more than 20 or 30 feet wide. Figure 1.

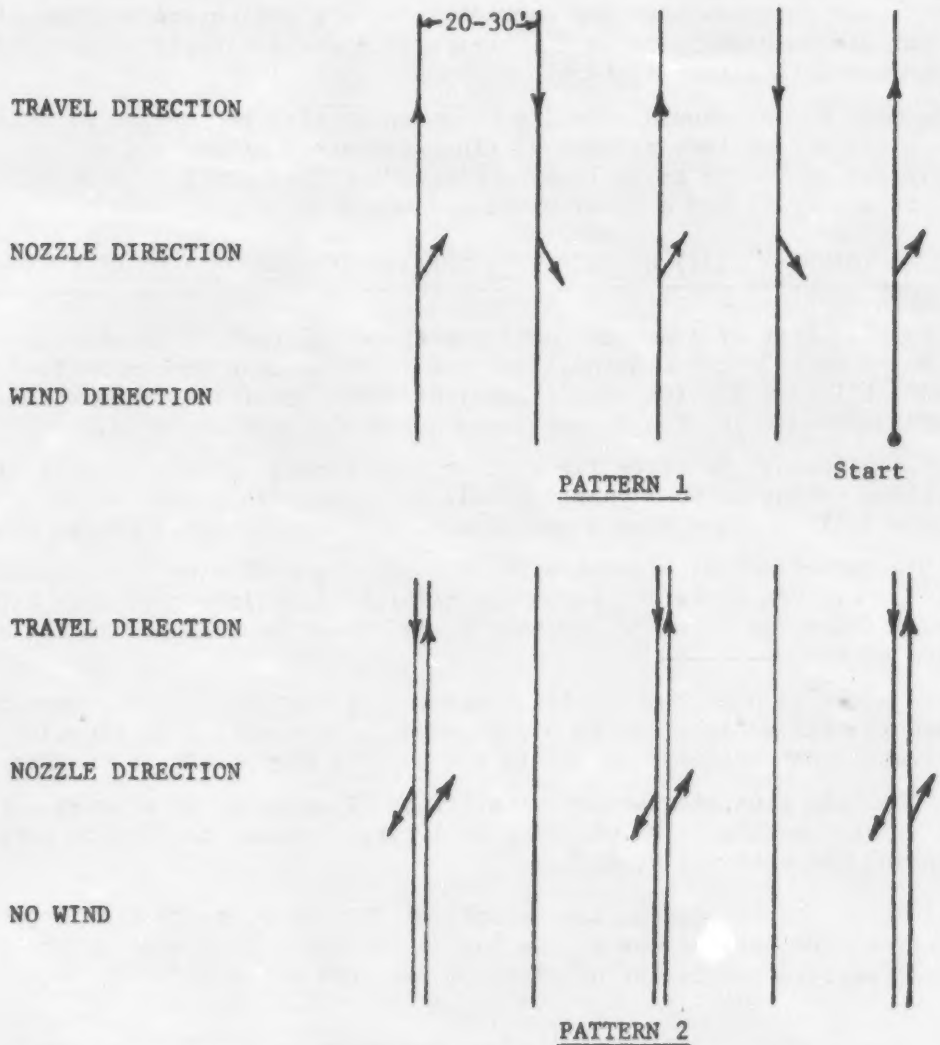

FIGURE 1. TRAVEL PATTERNS WHICH MAY BE USED WHEN SPRAYING.

In a plantation, one may walk along every third or fourth row, but in a natural stand it will generally be necessary to mark the strips with paint or flagging tape. Cleared trails make walking easier and it would be worth preparing such trails in advance. Mist spraying should always be done when air is calm or with a light breeze of no more than 2-3 miles per hour. Under these conditions the direction of the strips will not matter. However, it is easier and safer to walk along contours than up and down hill, and there are some advantages to spraying in the down-hill direction.

Even though conifers are relatively resistant to the herbicides used for brush control, damage to the foliage of crop trees can result if they receive the full output of the mist blower at close range. If the nozzle is carried waist-high and elevated at an angle of 45 degrees, only trees more than about 4 feet tall will be endangered. When passing near such trees, raise the nozzle to avoid giving them an overdose.

Stop spraying when moving from one strip to another. Either of the two travel patterns shown in Figure 1 may be used. Pattern 1 gives a complete and uniform coverage, especially if a breeze is blowing across the strips. In that event, spraying should begin on the down-wind side and the nozzle should be directed down-wind. Pattern 2 requires less flagging or trail cutting but is likely to give less uniform coverage and a crosswind might carry the chemical onto the operator. If the strips are not too wide, a light breeze blowing along the strips will not seriously affect the coverage obtained with either pattern.

The mist blower should normally be operated with the engine at full throttle to produce a uniform pattern of fine droplets. At reduced engine speeds, coverage is likely to be less complete, but when drift is a problem, it may be necessary to use a lower speed.

II. CHEMICAL THINNING (TSI) OF SEEDLING, SAPLING AND POLE STANDS OF CONIFERS, HARDWOODS OR MIXED WOODS

A partial list of chemicals used for these cut surface treatments include 2,4,5-T ester*, 2,4-D amine, Tordon (picloram-2,4-D concentration) Tordon 101R, Silvisar 510 (Cacodylic Acid) Silvisar 550 (MSMA, Monosodium methanearsonate). See Tables 2 and 3 for application rates.

2,4,5-T (ester) is effective against a wide range of species. It is slow acting, taking up to 3 years to kill maple and beach, but by using a complete frill, rather than a spaced cut, its effectiveness can be improved.

2,4-D (amine) chemical most effective in oaks with a complete frill at full strength. Red maple and beech are relatively resistant to this herbicide. In addition, it freezes in winter -- it is not recommended in the northern tier of states.

Tordon 101 is highly effective against a variety of species, especially the hard to kill maples. It is not recommended for aerial application for pine release. Any residual amount in the soil is phytotoxic to conifers.

In thinning pine plantations with Tordon "Flashback" is a problem but can be alleviated partially by diluting to 1 part chemical to 2 parts water and spacing the cuts (Cody, 1973.)

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* 2,4,5-T is not to be used on food crops, around homes, recreation areas, pond or ditch sites. Registered use of 2,4,5-T is for control of weed trees and brush on range, pasture and forest or rights-of-way and other non-crop land.

Tordon 101R - A new premixed chemical that is proving to be very popular, especially for use in the hypohatchet and injector where clogging problems are fewer.

Silvisar 510 - Effective in thinning pine stands, flashback can be excessive with complete frill and high concentration of chemicals. In the hardwoods Silvisar 510 and Tordon are similar in their effectiveness although Silvisar 510 is less effective in hard and soft maples, but more effective against the white oaks.

There is some question concerning its effectiveness in winter application. The literature suggests that it should not be applied in the winter.

Silvisar 550 - fast and effective against hardwoods and conifers and it is inexpensive as well. A problem restricting its use is there is not enough information on winter application to justify its use during that season. Particularly prolemsome in the hypo-hatchet if the chemical is allowed to set in the hatchet when not in use.

TABLE 2. RECOMMENDATIONS FOR CHEMICAL THINNING OF RED PINE AND WHITE PINE PLANTATIONS AND NORTHERN HARDWOODS.

Species	Chemical	Dilution[1]	Method[2] 4"-8" DBH	Method[2] 8"+DBH
Red pine	Tordon 101	1:2 (water)	SC	SC
	Silvisar 510	1:1 "	SC	SC
	Silvisar 510	1:2 "	SC	F
White pine	Tordon 101	1:2 (water)	SC	SC
	Silvisar 510	1:2 "	F	F
Hardwoods				
Hard maple[3]	Tordon 101	1:1 (water)	F	F
Soft maple[3]	"	" "	F	F
Beech	"	" "	SC	F
Basswood	"	" "	SC	SC
W. Ash	"	" "	SC	F
Cherry	"	" "	SC	SC
Other	"	" "	F	F
Hard maple[3]	Silvisar 510	Undiluted	F	F
Soft maple[3]	"	"	F	F
Beech	"	"	SC	SC
Basswood	"	"	SC	SC
W. Ash	"	"	SC	F
Cherry	"	"	SC	SC
Other	"	"	F	F

1 Water was the dilutent for all treatments except those applied in January when a 1:1 solution of water and methonal was used. Applications were made at temperatures as low as -16°F with no freezing problems.

2 F - Frill (Complete) SC - Spaced Cut

3 Season of year had little effect on the percent of kill achieved. However, early spring during sap flow, is the poorest time to treat.

Taken from Research Note #8, Applied Forestry Research Institute, Syracuse,N.Y.

TABLE 3. GENERAL RECOMMENDATION CONCERNING WOODY VINES

1) POISON IVY	Late spring applications most effective. During dormant season saturate stems with 5% 2,4,5-T in oil carrier.	(1) Foliage spray, amitrole (50%) 1 lb. in 25 gals of water. (2) 2,4,5-T (1/2%) in water. (3) picloram + 2,4-D at 1 gal in water to make 100 gals, applied as a full coverage spray or 3 gal/A in low volume spray.	Thoroughly wet all plant surface and woody stems using knapsack-type garden sprayer. Spot treat regrowth as required. Note: Use pictoram only where desirable trees with root zone in the treatment area are expendable.
2) JAPANESE HONEYSUCKLE	Foliage spray in late spring or summer. Control during dormant season is difficult.	(1) Foliage spray, amitrole (50%) 2 lbs in 25 gals water. (2) 2,4-D or 2,4-D +2,4, 5-T 2 to 3 lbs/100 gal. water. (3) Picloram 3 lbs/A in water.	Apply as foliage spray, thoroughly wetting all foliage and stems. Density of cover will determine volume of spray per acre. Spot treat regrowth as required. Generally requires a follow-up or second application. Do not use picloram where root zone of desirable trees extend into treated area.
3) GRAPE VINES	Foliage spray in June or July. During dormant season use basal spray.	Grape tangles: Foliage spray with 2,4,5-T, 4 lb/ 100 gal in water. In dormant season, basal spray with 2,4,5-T, 16 lb/100 gal oil.	Apply as foliage or basal spray depending on herbicide and season.

TABLE 4. REGISTERED HERBICIDES FOR TIMBER STAND IMPROVEMENT (9/75)

HERBICIDES	APPLICATION METHOD	COMPANY	TRADE NAME	EPA NO.
2,4-D Amine	injection	AmChem	Weedar*64	264-2AA
	injection	Rhodia	2,4-D Amine #4	359-331-ZA
	injection	Thompson-Hayward	Ded-Weed*40	148-140
	injection	Transvaal	Weed-Rhap*A-4D	11687-6-AA
	injection	Dow	DMA*4	464-196-AB
2,4-D+ 2,4,5-T Amines	frill, injection	AmChem	Weedar*Amine BK	264-53-ZA
2,4D + 2,4,5-T LV esters	basal bark, stump, frill	Dow	Esteron*Brush Killer	464-204-AA
	basal bark, frill, stump	Rhodia	Low volatile Brush Killer No.2	359-179-ZA
	basal bark, stump, frill	Thompson-Hayward	Ded-Weed*LV-33	148-211
	basal bark, frill, stump	Transvaal	Brush-Rhap*LV 2D-2T	11687-10AA
	basal bark, stump, frill	Transvaal	Brush-Rhap*LV oxy--2D-2T	11687-56
	basal bark, stump, frill	AmChem	Weedar*IBK	264-21-2A
	basal bark, stump, frill injection	AmChem	Dinoxol*	264-103AA
2,4,5-T LV esters		Dow	Esteron*245	464-302
		Rhodia	2,4,5-T low volatile ester 4L	359-178-ZB
	All registered for basal bark, frill and stump treatment	Thompson-Hayward	Ded-Weed*LV6	148-212
		Transvaal	Brush-Rhap*LV-4T	11687-7-AA
		Transvaal	Brush-Rhap* LV oxy-4-T	11687-43-AA
		Transvaal	Brush-Rhap*LV-6T	11687-27-AA
		Transvaal	Brush-Rhap* LV oxy-6T	11687-63-AA
		Thompson-Hayward	Ded-Weed* LV-9 Brush Kill	148-431

HERBICIDES	APPLICATION METHOD	COMPANY	TRADE NAME	EPA NO.
2,4,5-TP	basal spray, stump	Dow	Kuron*	464-162-AA
	stump	Rhodia	Silvex 4L	359-366-ZA
Cacodylic acid	injection	TSI	Silvisar*510	29301-2
Dicamba	injection	Velsicol	Banvel*4-WS	876-159-AA
Dicamba & 2,4-D (Amine or LV esters) or Dicamba & 2,4,5-T or 2,4-D LV ester	basal, bark	Velsicol	Banvel*4-WS	876-159-AA
			Banvel*4-OS	876-156-AA
			Banvel*310	876-180-AA
			Banvel*320	876-179-AA
			Banvel*510	876-169-AA
			Banvel*520	876-168-AA
			Banvel*710	876-176-AA
			Banvel*720	876-177-AA
Ammonium sulfamate	stump, frill, notch method	Dupont	Ammate*X-NI	USDA-352-311
Picloram + 2,4-D	injection, frill, stump	Dow	Tordon*101R	464-510
		Dow	Tordon*1C1	464-306-AA
MSMA	injection, frill	TSI	Silvison*550	29301-1

* Registered Trade Name

FOREST TREES

GENERAL DISEASES

LEAF SCORCH

Leaves of ash, beech, dogwood, elm, maple, and oak often are affected by a noninfectious disease which causes a browning between veins or along margins of the leaves. Scorch usually develops during July and August and is especially severe following periods of drying winds and high temperatures, when the roots are unable to supply enough water to the tree to replace the large amount of water lost through the leaves. The condition may also result from shallow soils, roots which girdle the base of the tree, a diseased root system, drought, and diseases which weaken the tree. Fir, pine, and spruce often show leaf scorch as a brown discoloration of needle tips. Scorch on needles may be the result of hot, dry weather or of high winds during cold weather.

POWDERY MILDEW

Fungi of the powdery group infect the leaves of various trees, producing patches of white or gray powdery coating on the leaf surface. Tiny black fruiting bodies of the powdery mildew fungus are often found on the white patches. Forest trees commonly affected with powdery mildew in New Hampshire are dogwood, sycamore, and tulip poplar.

SOOTY MOLD

Various fungi grow as saprophytes on honeydew secretions of such insects as aphids and scales. These fungi form a heavy sooty growth which partially or completely covers the needles of several evergreens and the leaves of elm, linden, magnolia, maple, and tulip trees. Although the heavy coating of mold on leaves is unsightly, it does not seem to interfere seriously with food manufacture within the leaf.

DISEASES OF SPECIFIC TREES

ASH

Anthracnose or Leaf Spot -- The fungus, Gloeosporium aridum, causes large irregular brown spots, usually along the edges of the leaves. Affected leaves fall prematurely. The fungus overwinters in fallen diseased leaves.

Leaf Scorch -- See GENERAL DISEASES

Rust -- The fungus, Puccinia sparganioides, causes swollen distorted areas on leaves and twigs. The swollen areas become covered with minute cups, within which yellow powdery spore masses develop. These spores cannot reinfect ash leaves and twigs, but they infect certain marsh grasses on which overwintering spores are formed. Reinfection of ash occurs in the spring from spores formed on grasses.

ASPEN

See POPLAR

BASSWOOD

See LINDEN

BEECH

Beech Bark Disease -- This disease, caused by the combined attack of the wooly beech scale and the fungus Nectria coccinea. Infestations of the scale always precede the attack on the tree by the fungus. The fungus is not capable of damaging a tree in the absence of the scale insects. Feeding punctures of the scale insects serve as points of entrance for the fungus which kills the bark. As large areas of the bark are killed the tree declines and dies. The disease may kill many beech trees in forested areas.

BLACK LOCUST

Brooming Disease -- A virus causes abnormal development of buds into short, spindly shoots which have smaller than normal leaves. Buds on these spindly branches also develop abnormal branches, resulting in the broom-like appearance of the tree. The brooming usually occurs late in summer, and the shoots often die during winter. Roots of infected trees are shorter, darker, and more brittle than normal. Excessive rebranching of the roots gives a broom-like appearance to the roots.

BUTTERNUT

Dieback -- The fungus, Melanconis juglandis, produces a dark discoloration of the bark on small branches, causing a dieback which progresses down the branches to the trunk. The severely affected trees eventually die. Dead branches are covered with small, black, pimple-like fruiting bodies of the causal fungus. In wet weather, spores ooze out in a black inky mass from fruiting bodies and are splashed and blown to infect other branches.

Anthracnose or Leaf Spot -- This fungus-caused (Gnomonia leptostyla) disease creates irregular dark-brown spots on the leaves. Severe infection results in premature defoliation.

CHESTNUT

Blight -- This disease is caused by the fungus Endothia parasitica. Cankers form on twigs, branches, and trunks of infected trees. On young wood the cankers are swollen, yellow-brown, oval or irregular areas. On older wood they are brownish, circular or irregular areas with slightly raised or depressed edges. Partial or complete girdling of stems by cankers causes leaves to yellow and brown. Dead leaves and burrs cling to diseases branches long after normal leaf fall.

The surface of older cankers is covered with minute pinpoint fruiting bodies of the blight fungus. During wet weather, yellowish spore masses ooze from fruiting bodies. These spores are carried by rain, birds, and insects. New infection follows when spores enter through wounds.

American and European chestnuts are very susceptible to this disease. Chinese and Japanese chestnuts are resistant but not immune.

Leaf Spot -- The causal fungus, Marssonina ochroleuca, infects leaves causing small, circular, yellow to brown spots with concentric markings. The spots may drop out and leave small holes in the leaf. Premature defoliation may follow.

DOGWOOD

Crown or Trunk Canker -- The disease is caused by a fungus, Phytophthora cactorum. Trees with low vitality, particularly those growing in poorly drained soil or those suffering from drought, are often infected. The leaves of infected trees, smaller and lighter green than normal, turn red prematurely in late summer. Later, twigs and even large branches die. A canker may be found on the lower trunk at or near soil level where the fungus invaded bark, cambium, and outer sapwood and caused a discoloration of infected tissues. The cankers enlarge slowly for several years, extend completely around the base of the trunk or root collar, and kill the tree. For a few years before their death, infected trees often bear large flower and fruit corps.

Flower and Leaf Blight -- Flowers are infected at the end of their bloom period. The fungus, Botrytis cinera, causes irregular, brown, wrinkled patches on the bracts. If the weather remains humid, these patches may be covered with a grayish mold. Infected bracts may fall on the young leaves and cause leaf infections. Infected leaves may fall, but the leaf drop is usually not serious.

Leaf Scorch -- See GENERAL DISEASES.

Leaf Spot -- Angular grayish spots with dark purple margins occur on leaves. The disease, caused by the fungus Septoria cornicola, is most common during wet seasons.

Powdery Mildew -- See GENERAL DISEASES

Spot Anthracnose -- A fungus, Elsinoe corni, causes a spotting of the flowers and of the leaves, stems, and fruit. The spots on bracts are reddish-purple and may be as large as 1/10 inch in diameter. Spotting of bracts may be so severe that flowers are disfigured. Badly infected flower buds may never open.

Spots on leaves appear as circular to angular dark purple areas usually less than 1/25 inch in diameter. Diseased leaf tissues often drop out, leaving holes or ragged edges. Severely infected leaves may be reduced in size or be killed.

Spots on fruit and stems may be abundant. The surrounding tissue may be dark, and the spots are often slightly raised.

Twig Blight — Twigs of native dogwood die back. This disease, caused by the fungus Myxosporium everhartii, may be confused with the more extensive dying back of trees infected with crown canker.

ELM

Black Leaf Spot -- This disease is caused by the Gnomonia ulmea. Leaves become infected as they unfold in the spring; grayish, irregular spots occur on the upper leaf surface. Later the spots enlarge to about 1/8 inch in diameter and shiny black dots appear in the center. Infected leaves turn yellow, and during wet seasons, premature leaf-fall may be heavy.

Dothiorella Wilt or Dieback -- The fungus, Dothiorella ulmi, infects trees through wounds, causing a wilting and yellowing of leaves. Cankers are formed which cause a dieback of affected branches. Diseased bark on the cankers becomes shrunken and reddish-brown with black, raised pustules appearing in the dead bark. A brown discoloration of the sapwood may be confused with that caused by Dutch elm disease or Verticillium wilt.

Dutch Elm Disease -- Dutch elm disease was first observed in the United States in Ohio in 1930. Since then it has spread throughout the east and as far west as Idaho. All American elm species are susceptible. This disease has eliminated elms from many eastern and midwestern communities.

Dutch elm disease is caused by a fungus, Ceratocystis ulmi, which invades and plugs the water-conducting system of the tree. The foliage wilts and turns yellow, usually first on one or more individual branches, but soon on the whole tree. Leaves may curl and turn yellow before falling, or may wither and fall suddenly while still green. Infected trees may die within a few weeks or may decline slowly over a period of one year or more. Affected branches develop a brown discoloration in the outer layers of sapwood just under the bark. On the ends of cut twigs, the discoloration may appear as a complete browning of one or more of the outer-most annual rings.

The causal fungus is carried from tree to tree by two species of elm bark beetles -- the smaller European elm bark beetle and the native elm bark beetle.

The infection cycle begins in the spring during May when adult bark beetles emerge from infected trees. If overwintering took place in trees killed by Dutch elm disease, then many of the emerging beetles will have sticky spores of the Dutch elm fungus on their bodies. The emerging beetles seek living, healthy elms where they feed in crotches of small twigs. Fungus spores are deposited in water-conducting tubes opened by the feeding injury. Elms so inoculated usually develop the disease during that summer. The majority of the beetles feed 600 feet or less from the dead wood in which they overwintered. Where elms are scarce, beetles may fly several miles in search of feeding sites.

After feeding for a few days, the beetles seek a suitable egg-laying site. They require dying or recently dead elm wood with the bark still tightly attached. This may be a standing dead tree, a log, a weakened tree, or a weakened branch on a healthy tree. Wood also may be inoculated during the egg-laying activities of beetles carrying the fungus. Thus, elms weakened or killed by any means may become infected with the fungus and become a source of a new brood of infectious beetles.

Beetles will not infest wood without bark or with loose, cracked bark such as that on old logs or on trees dead more than a year. Beetles reproduce in all species of elm.

Although broods of bark beetles may occur every 35 to 40 days during the summer, much of the spread of the disease is associated with the feeding injuries of the first spring brood. At this season, the long water-conducting tubes in the wood of elms are near the surface and are easily opened by the beetles' feeding.

An important factor in the spread of the disease is the egg-laying site of the last brood of the season. If these adults lay eggs in Dutch-elm-disease-killed trees, it is likely that beetles emerging next spring will be coated with fungus spores. If such trees are removed during the winter, the threat of infection is greatly reduced.

Elms Resistant to Dutch Elm Disease -- Although none of the species of elms is immune to Dutch elm disease, some are highly resistant; however, these species are smaller and lack the desirable vase-shaped form of the American elm. Resistant species are Ulmus pumila, the Siberian elm, and Ulmus parvafolia, the Chinese elm. A Netherlands elm, the Christine Busman elm, is also resistant. However, this selection is susceptible to the elm leaf beetle and is not winter hardy in the northernmost range of the American elm.

Leaf Scorch -- See GENERAL DISEASES

Phloem Necrosis -- This destructive disease of American elms is caused by a mycoplasma. Leaves turn bright yellow, then brown, and they finally fall off. Trees infected during spring or early summer may live through the winter, produce a thin crop of leaves, and die the next summer.

The inner layers of bark of the roots and lower trunk of affected trees, when freshly peeled, show a butterscotch color and have a faint odor of wintergreen. The mycoplasma causing this disease is spread from tree to tree by leafhoppers.

Sooty Mold -- See GENERAL DISEASES

Verticillium Wilt -- Leaves yellow and wilt. Browning of the sapwood under the bark resembles that caused by Dutch elm disease.

Wetwood (slime flux) -- The bacterium Erwinia nimipressuralis causes this disease by infecting the wood of elm and other hardwoods, such as maple, birch, oak, poplar, sycamore, and willow. The infection results in an increase of internal sap pressure. Sap seeps out of infected areas through cracks, wounds, and pruning cuts and flows down the trunk soaking large areas of bark.

The seepage often becomes contaminated with bacteria and yeasts, resulting in a foul-smelling substance called slime flux. The slime flux may prevent healing of wounds and may kill bark and wood over which it flows. Toxic sap from infected wood may be carried to branches, where wilting and defoliation may occur. A browning of the tissues between veins along edges of leaves is found on affected branches. The wood under the bark of wilted branches often shows grayish-brown streaks similar to those found with Dutch elm disease.

HACKBERRY

Witches'Broom -- A powdery mildew fungus and a specific gall mite are usually associated with broom-like growths on branches of hackberry. Several hundred galls may be found on a single tree, causing an unsightly appearance in the winter. Affected branches are weakened and break easily during wind storms; the broken wood is exposed to wood-decay fungi. Affected buds are larger and more open and hairy than normal. Mites may be found inside the buds along with small black fruiting bodies of the mildew fungus. Thread-like strands of mildew are found on the outside of the bud. Branches that develop from these buds are dwarfed and clustered, giving the witches' broom effect.

HAWTHORN

Rust -- Rust on hawthorn may be caused by either of two fungi. The fungus Gymnosporangium clavipes causes severe deformation of leaves, twigs, and fruit. The orange-colored spores of the causal fungus are produced in tiny whitish tubes on the surface of the fruit and on swollen parts of the twigs.

Another fungus, G. globosum, infects leaves, causing gray to brown spots. The fruit also may be infected and covered with the brownish horn-shaped fruiting bodies. Both of these rust fungi require the presence of red cedars and other species of juniper for continued spread of the disease.

HEMLOCK

Twig and Branch Canker -- Cankers caused by the fungus Cytospora sp. form on twigs and branches. Branches girdled by cankers die. Embedded fruiting bodies of the causal fungus break through the bark of the cankers and produce thread-like masses of spores during wet weather.

HICKORY

Leaf Spot -- A fungus, Gnomonia caryae, causes irregular, reddish-brown spots on the upper leaf surface and brown spots on the lower leaf surface. Severe infection may cause leaf fall. The fungus overwinters in fallen leaves.

JUNIPER, RED CEDAR

Rusts -- The causal fungus, Gymnosporangium juniperi-virginiana, stimulates leaves of red cedar to form small, deep-red smooth, globular galls in the first spring after infection.

The galls mature in the second spring after infection, and may be as large as two inches in diameter. Galls are greenish-brown, globular to irregular-shaped, and corky. Their surface becomes covered with small pit-like depressions, the center of each pit having a small pimple-like protuberance. During spring rains, many gelatinous, orange spore-horns protrude from these horns are carried by wind and insects to leaves or fruits of nearby alternate host plants such as apple and ornamental crab-apple. These alternate host plants are needed for the completion of the life cycle of the rust fungus, since the spores produced on juniper are unable to reinfect juniper. If the alternate hosts are removed, the life cycle is broken and the rust fungus cannot survive.

Other rust fungi commonly found on junipers are hawthorn rust, which forms smaller galls on the leaves; quince rust, which forms slight swellings on twigs and branches; and serviceberry or shadbush rust, which stimulates the formation of witches' brooms.

LINDEN, BASSWOOD

Anthracnose or Leaf Blotch -- The fungus Gnomonia tiliae, causes small, circular to irregular brown spots which grow together and form blotches along the main veins of leaves, leaf stems, and twigs. A conspicuous black margin is found between healthy and dead tissue. In wet seasons, leaf fall may be severe.

Leaf Scorch -- See GENERAL DISEASES

Leaf Spot -- The causal fungus, Cercospora microsora, infects leaves, causing small, circular light-brown spots with dark margins. Where the spots are numerous, they may grow together and cause leaves to fall prematurely.

Powdery Mildew -- See GENERAL DISEASES

Sooty Mold -- See GENEKAL DISEASES

MAPLE

Anthracnose -- On Norway maple, narrow, purple to brown streaks occur along the veins of leaves; on sugar maple, large, irregular, green-brown or red-brown areas occur along and between the veins extending out to the edge of leaves. On sugar maple, infected leaves may be confused with leaves showing scorch symptoms resulting from drought and heat injury. (Small brown fruiting bodies of the causal fungus, Gloeosporium apocryptum, are found along the veins of leaves infected with anthracnose, and are not found on leaves showing scorch symptoms.) During wet seasons, infection may be severe enough to cause partial defoliation.

Leaf Spot -- The fungus, Phyllosticta minima, infects leaves causing small, irregular, circular brown spots, with a pronounced purple border. The spots may be only one-quarter inch in diameter, or they may grow together to involve half the leaf. Tiny black fruiting bodies of the causal fungus are formed on the upper surface of the spots. In wet seasons, leaf fall may be heavy.

Leaf Scorch -- See GENERAL DISEASES

Sooty Mold -- See GENERAL DISEASES

Tar Spot -- Two fungi infect the leaves of red and silver maple, causing oval to irregular, shiny black, thickened, raised spots. One fungus, Rhytisma acerinum, causes spots about 1/4 to 1/2 inch in diameter; the spots caused by the other fungus, R. punctatum, are not more than 1/8 inch in diameter and they create a more speckled effect on the leaves.

OAK

Anthracnose -- Leaves of infected white oaks have brown dead areas that follow the veins out to the edge of the leaf. Severely affected leaves become curled and twisted, and in wet seasons, leaf fall may be common. Leaves on the lower branches are generally more severely affected than those on the upper branches. The fungus, Gnomonia quercina, may spread into the twigs, forming cankers which may result in twig dieback.

Large Leaf Spot -- In late summer, the causal fungus (Monochaetia desmazierii) infects leaves of white and red oaks, causing circular spots up to 2 inches in diameter. The spots have pale green or yellowish centers and reddish-brown margins. Target-like rings may be formed around the spots as the disease progresses.

Leaf Blister -- During cool, wet springs, this fungus, Taphrina coerulescens, infects leaves of red and other oaks, and causes circular, raised, wrinkled, yellowish-white areas up to 1/2 inch in diameter on the upper leaf surface. Affected leaves remain attached to the tree and usually continue to function as normal leaves.

Leaf Scorch -- See GENERAL DISEASES

The disease-causing fungus, Ceratocystis fagacearum, invades and plugs the water-conducting system of the tree. The leaves wilt, turn bronze (usually on one or more branches at first), and then fall. Premature shedding of foliage is a visible diagnostic symptom of oak wilt. Infected trees of the red oak group die within a few weeks or may decline slowly over a 2- to 3-year period. Some infected white oaks may recover.

Affected branches develop a brown discoloration in the outer layers of sapwood just under the bark. On the ends of cut twigs, the discoloration may appear as a complete browning of one or more of the outermost annual rings.

The fungus may be carried from tree to tree by various insects. Sap-feeding beetles are of major importance in short-range spread of the fungus. Trees that wilt in late summer or early fall may bear spore-producing mats of the causal fungus under their bark during the following spring. As these mats develop, the bark ruptures, exposing the fungus. The odor of the mats attracts sap-feeding beetles which also feed on the fungus and become coated with the sticky spores. If these insects then feed on fresh bleeding wounds on healthy trees, fungus spores are deposited in water-conducting tubes opened by the injury. Research indicated that oak bark beetles which breed under the bark of dying trees and feed on small twigs and branches may be responsible for long-range spread of the fungus.

Susceptibility of oaks to oak wilt -- All tested species of the red oak group are very susceptible and normally die with a few weeks of infection. Although no species of the white oak group is resistant, some species contain resistant individuals. White oak is more resistant than chestnut oak or bur oak. American, Chinese, and European chestnuts, tanbark oak, and bush chinquapin are susceptible.

Twig Canker -- The fungus, Diplodia quercus, infects twigs of chestnut and other oaks, causing a sudden blighting of leaves on occasional twigs and branches. Dead leaves remain attached to twigs and give the tree the appearance of severe locust injury. On trees growing on rocky ridges or suffering from prolonged drought, the fungus may kill large branches or even the entire tree. Fruiting bodies of the causal fungus are found on blighted twigs.

PINE

Needle Blight -- This disease appears on current growth of white pines. From late spring to mid-summer the new needles brown and die back, from the tips downward. The needles are often stunted. The cause of blight is unknown; an inadequate root system, injury to the small feeding roots, or poor soil conditions may be involved.

Needle Cast -- This disease is caused by the fungus Lophodermium pinastri. Scotch pines are susceptible to needle cast. It is particularly severe on the French and Spanish strains of Scotch pine, but also occurs on Austrian, red, and eastern white pines in nursery seed beds.

Infection occurs during the summer on the current year's needles, but no symptoms appear until the following spring when the infected needles turn yellow to brown and fall from the tree. On these fallen needles, the fungus produces spores which are ejected from fruiting bodies and are carried by wind currents to infect the new needles. Initial infection often occurs on the lower branches of the trees.

Spore production and infection are dependent on abundance of moisture in the form of frequent rains or long-lasting dews. Thus, this disease often appears first next to dense woods where the dew persists or on the lower portions of trees in plantations where weeds have not been controlled. The dense stands of seedlings in seedbeds offer ideal conditions for infection.

Needle Rust -- This rust fungus, Coleosporium asterum, attacks needles of two- and three-needle pines. Red pine is very susceptible. The disease develops in spring as small, cream-colored, bag-like pustules on needles. The pustules rupture, and orange spores are blown to infect goldenrod and asters. The rust overwinters and can live indefinitely in the crowns of these alternate hosts. During summer and autumn, spores from goldenrods and asters infect needles of the pines. This disease may cause needle drop and may stunt young pines, but it seldom causes much damage on older trees.

Tip Blight -- The fungus, Diplodia pinea, causes a tip dieback of branches of Austrian, red, Scotch, and mugho pines. Tiny, black fruiting bodies of the causal fungus grow at the base of diseased needles and on dead twigs and cones.

White Pine Blister Rust -- The rust fungus, Cronartium ribicola, infects and kills needles of white pine and then grows into the bark of twigs and branches. Swollen, oval cankers enlarge to girdle and kill stems and branches. Trees are killed when cankers completely girdle the trunk. Three or four years after infection, yellow spore masses are produced and are carried by wind to infect nearby currants and gooseberries. Rust spores formed on the leaves of these alternate hosts cause new infection of white pines.

POPLAR

Leaf Rust -- A rust fungus, Melampsora abietis-canadensis, produces yellowish-orange powdery pustules on the lower leaf surface. Hemlock is the alternate host for this fungus.

Scab or Shoot Blight -- This disease is caused by the fungi, Venturia populina and V. tremulae. Young leaves become black and wilt. In some cases, particularly on quaking aspen, the fungus may spread down the petiole and blacken the shoot, which then withers and appears hooked. Under moist conditions, dark-greenish spores of the fungus are formed on affected leaves and shoots.

RED CEDAR

See JUNIPER

SPRUCE

Cytospora Canker -- The causal fungus, Cytospora kunzei, attacks Norway and Colorado spruce, causing death first of the lower branches and then progressing to higher branches. The cankers produced on affected branches are inconspicuous. They may be covered with resin, which often drips to cover lower branches. During rainy weather, thread-like, yellowish, gelatinous spore masses ooze from fruiting bodies on the cankers. These spores are spread by rain, wind, or birds to other spruces, where they enter through wounds.

SYCAMORE

Anthracnose -- This fungus, Gnomonia platani, causes twig, bud, shoot, and leaf blight. Twig blight occurs before leaves appear in the spring, and kills the tips of one year-old twigs. Small black fruiting bodies of the causal fungus appear in the bark of the dead twigs. Cankers may girdle the twigs. Repeated annual killing of twigs results in gnarled or bunchy branch growth.

Bud blight occurs as cankers on the twigs, and causes the buds to die before they open.

Shoot blight, which appears as a sudden dying of expanding shoots and immature leaves on affected branches, is often confused with frost injury. Leaf blight occurs when spores produced on the twig and branch cankers infect expanding or mature leaves. Affected leaves show irregular dead areas along the veins. Dark-brown fruiting bodies of the fungus are found on diseased leaf tissue. The fungus often grows through leaf stems into the twigs, where it becomes active the following spring.

Powdery Mildew -- See GENERAL DISEASES

TULIP POPLAR

Leaf Spot -- The fungus-caused (Gloeosporium liriodendri) leaf blotches have dark-brown borders and may be up to 1/2 inch in diameter.

Leaf Yellowing or Scorch -- During hot, dry periods in mid-summer, leaves of recently transplanted or weakened trees may turn yellow and drop prematurely. Small angular, brownish specks often appear between the veins of affected leaves. The yellowing and scorch result when roots fail to supply enough moisture to replace that lost during hot, dry periods.

Sooty Mold -- See GENERAL DISEASES

WALNUT, BLACK

Anthracnose or Leaf Spot -- The fungus, Gnomonia leptostyla, causes irregular dark-brown spots on leaflets. Severe infection results in premature leaf fall.

COOPERATIVE EXTENSION SERVICE

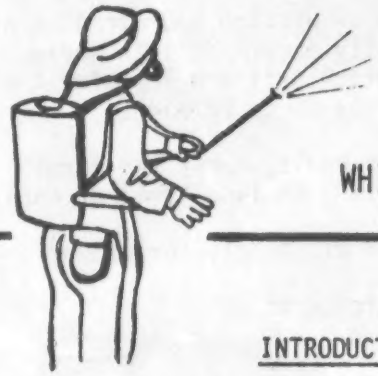
University of New Hampshire

Pest Fact Sheet

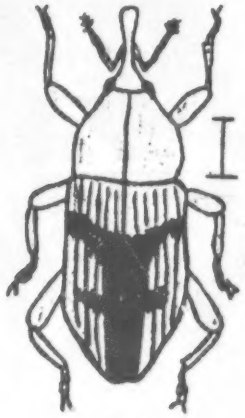
No. 14

PESTICIDE APPLICATOR TRAINING

GREENHOUSE AND NURSERY



WHITE PINE WEEVIL



adult

larva

INTRODUCTION

The White Pine Weevil is the most destructive insect pest of eastern white pine in North America. Norway spruce, jack pine, Scotch pine, pitch pine, red pine, blue spruce, and white spruce are also susceptible to White Pine Weevil damage. Damage from this weevil results in reduction of lumber yield for lumbermen and poor quality ornamentals for nurserymen.

DESCRIPTION OF THE WHITE PINE WEEVIL

Larvae of the White Pine Weevil are slightly larger than the adult (5-7 mm), are yellowish-white in color, and are legless.

The adult is a snout beetle about 4-6 mm in length. The wing covers (elytra) are marked with brown and white scales with a white patch of these scales at the tip of these wing covers.

The resting stage is a creamy-white pupa and is the same length as the adult (4-6 mm).

LIFE CYCLE

The adult White Pine Weevil overwinters in litter on the ground. From April to May, they emerge and begin to feed on the terminal growth. They favor feeding on the bark 7-10" below the dormant terminal buds.

Eggs are then deposited in the bark of the terminal and hatch in 7-10 days.

The developing larva feeds on the inner bark until maturity in July. Pupation occurs in the larval chambers and the adult then emerges in 10-15 days and continues to feed on old and new growth. The adult feeding does as much damage as the larval feeding.

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CONTROL

At the first sign of wilting and drooping of terminals, check for excessive pitch flow. This usually occurs in late spring. If excessive pitch flow is found, cut open the area of pitch exit and look for the larvae. If found, remove the entire leader and destroy it by burning.

For control of the adult, spray the terminals with *Lindane** in early April, or with *Meta-Systox-R** (0.5%) in late April or early May.

Make sure to check all labels for proper application and rates.

* Restricted use pesticide in N.H.

SUMMARY

1.	Damaging Stage:	Adult and Larva
2.	Part of Plant Attacked:	Terminal Leader
3.	Overwintering Stage:	Adult
4.	Number of Generations Per Year:	1
5.	Time of Year When Damage Done:	April - May (Adult and Larva)
6.	Number of Applications Per Year:	1

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed. Avoid inhaling dusts or sprays. Open windows and ventilate the rooms while using pesticides. Never smoke or eat while spraying or dusting. Remove or cover food, feed, water, kitchen utensils and fish and other pets. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

James S. Bowman
Jon P. Turmel

Extension Entomologists

1/76/1.5M

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS

Pest Fact Sheet

No. 29

FALL WEBWORM AND EASTERN TENT CATERPILLAR

fall webworm

eastern tent caterpillar

INTRODUCTION

The Fall Webworm (Hyphantria cunea, Drury) and the Eastern Tent Caterpillar (Malacosoma americanum, Fabricius) feed on fruit, shade, and woodland trees. They are of little economic importance in orchards which are regularly sprayed for the control of Codling Moth and other pests, but because they form unsightly webs, they can be considered a significant pest of nurseries and landscape. The Fall Webworm is frequently confused with the Gypsy Moth. The dirty loosely-woven web of the Fall Webworm encloses branches; the larvae can be found feeding within the web. The web of the Eastern Tent Caterpillar, on the other hand, is thickly constructed in the forks and crotches of trees; the larvae do not feed within their webs, but congregate there at night and during rainy weather. Fall Webworm occurs in the fall, whereas Eastern Tent Caterpillar occurs in the spring.

DESCRIPTION

FALL WEBWORM: The full-grown larvae are about 1½" long. They may be yellow with dark stripes and spots, or they may be dull bluish black with no yellow. The body is very hairy and the head is dark. The adult moths have a wingspan of 1½". Their color is nearly pure white.

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EASTERN TENT CATERPILLAR: The full-grown larvae are about 2" long and have sparse hairs. They are black with white and blue markings and have a white stripe down the middle of the back. The adult moths are reddish-brown in color with two whitish stripes running obliquely across each forewing.

LIFE CYCLE

FALL WEBWORM: There is one generation of the Fall Webworm per year. It overwinters as a pupa in the soil. In June and July, adult moths emerge from the soil and the females begin laying eggs in July. The eggs begin to hatch in late July - early August, and the larvae feed within the web for a month or more, crawl down the tree, construct a cocoon, and pupate.

EASTERN TENT CATERPILLAR: There is one generation of the Eastern Tent Caterpillar per year. It overwinters in egg masses on twigs of trees. They hatch in the spring, about the time the buds open. After feeding for two days, the larvae weave their tent. Successive layers are added to the tent as the larvae develop. Early in the summer, the larvae spin a cocoon, pupate, and emerge as adults. The females deposit masses of eggs in bands around twigs. The larvae develop inside the eggs, but do not hatch until the next spring.

CONTROL

Early detection of nests of either pest is important to avoid excessive defoliation. Destroying the nests by pruning out or burning can be done to a limited extent. Pesticides should be applied to hard-to-reach infestations or when populations are heavy. Spray foliage with methoxychlor, carbaryl, diazinon, Dylox, or Bacillus thurengiensis according to the label.

SUMMARY

		Fall Webworm	E. Tent Caterpillar
1.	Damaging Stage:	Larvae	Larvae
2.	Part of Plant Attacked:	Leaves	Leaves
3.	Overwintering Stage:	Pupa	Egg
4.	Number of Generations Per Year:	One	One
5.	Time of Year When Damage Done:	Fall	Spring
6.	Number of Applications Per Year:	As Needed	As Needed

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

James S. Bowman
Extension Entomologist

2/76/1.5M

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 37

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS

SCALE INSECTS

Oyster Shell Scale

Euonymus Scale

Fletcher Scale

Cottony Maple Scale

DESCRIPTION OF SCALE INSECTS

In appearance, scales in general show little resemblance to the typical insects. They are well protected because they live under a waxy, almost impermeable shell. The female lays her eggs under the shell which offers them protection. When the eggs hatch, the "crawler" stage is motile and will crawl about on the host plant to select a feeding site. It is during the crawler stage of development that scales are easily killed with insecticides.

Except for the males of some species, adult scales are permantly affixed to a position selected during the crawler stage. Scale infestations frequently go undetected until the infected plant is completely encrusted. The needle-like mouth parts are inserted into the plant and sap is withdrawn. Scales also secrete a clear sticky substance called honeydew which will coat objects below infested plants. Honeydew in turn will support the growth of a black fungus called sooty mold.

Scale insects vary in size, shape, color, host preference, and life cycle. The following species are common to New Hampshire trees and shrubs.

1. Oyster Shell Scale: Brown oyster shell shape about 1/8" long. They are found on twigs of lilac, ash, red bud, dogwood, poplar, willow, horsechestnut, elm, beech, walnut, cottoneaster, apple, birch, pachysandra, and others. The winter is passed as white eggs under the scale coverings. The eggs hatch in May, about the time the lilac blooms begin to fade. They become mature by August. There is one generation per year.

2. Euonymus Scale: This scale is obvious as brownish encrustations of the stems and twigs, and whitish spotting of the leaves, mainly on the underside. The primary

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host is euonymus, but it is also found on pachysandra and celastris (bittersweet). The winter is spent as the female on the stems and leaves. The young crawlers are produced in May or early June. A second generation occurs in mid-summer.

3. Fletcher Scale: The adult female is light yellowish-brown, almost globular, and about 3-5 mm in diameter. It commonly attacks Taxus, juniper, and arborvitae. It overwinters as a female and the eggs are laid in late May and hatch by early July. Foliage on the inner portions of heavily infested plants is often blackened by the sooty mold growing on the honeydew excreted by the scales. There are two generations per year with crawlers appearing again.

4. Cottony Maple Scale: This scale is best identified by the mass of white wax protruding from beneath brown scales, about ⅛" long. It is found on maple, boxelder, basswood, ash, sycamore, beech, black locust, willow, poplar, and occasionally elm; the favorite host is silver maple. The overwintering female lays eggs from April to June and they hatch in June and July. In heavy infestations branches may be killed, the foliage turns a sickly yellow, and honeydew drips on objects below upon which sooty mold grows.

CONTROL

SPECIES	STAGE	WHERE TO TREAT	WHEN TO TREAT	WHAT TO USE
Oyster Shell Scale	Egg	Bark of Twigs and Branches	April	60-70 sec. oil or oil + ethion
	Crawler	Bark of Twigs and branches	Late May to Early June	carbaryl or malathion + methoxychlor
Euonymus Scale	Nymph	Twigs and Stems	Mid-April to Early May	60-70 sec. oil or oil + ethion
	Crawler	Twigs and Stems	Early to Mid-June	malathion + methoxychlor or dimethoate or *Meta-Systox-R** or carbaryl
Fletcher Scale	Nymph	Foliage and Twigs	Mid-April to Early May	60-70 sec. oil or oil + *Guthion**
	Crawler	Foliage and Twigs	July and Sept.	malathion or carbaryl or diazinon or *Meta-Systox-R**
Cottony Maple Scale	Crawler	Twigs	Late June and July	malathion or carbaryl

* Restricted use pesticide in N.H.

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

2/76/1.5M-es

James S. Bowman
Extension Entomologist

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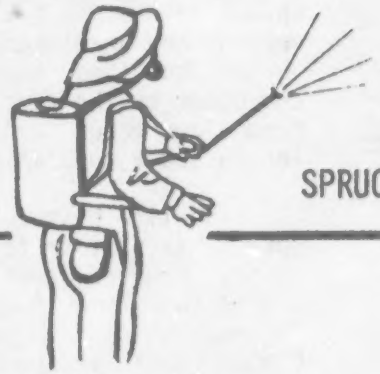
University of New Hampshire

Pest Fact Sheet

No. 38

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS



SPRUCE GALL APHIDS

INTRODUCTION

Most spruce trees are damaged by one of two species of aphids, the Eastern spruce gall aphid (Adelges abietis L.) and the Cooley spruce gall aphid (Adelges cooleyi Gill.). With their sucking mouthparts, they feed on plant juices causing an irritation to adjacent plant tissue which then develops into cone-like galls which are characteristic in form and shape for the aphid species involved. Continued infestations will disfigure ornamental trees, weakening them and making them subject to attack by other pest organisms.

DESCRIPTION AND LIFE CYCLE

Eastern Spruce Gall Aphid: Galls caused by this insect occur mostly on Norway, white, black, and red spruce trees. An infestation does not spread rapidly from one tree to another. It is not unusual to find specific trees in a planting rather heavily infested year after year while others of the same species may escape injury.

The Eastern spruce gall aphid lives during the winter as an immature female, usually located in a crevice at the base of a spruce bud. It begins feeding in early spring and in May deposits a mass of eggs which is covered with waxy threads. The eggs hatch about the time the shucks break away from the bud and expose the new needles. The newly hatched aphids crawl into the mass of new needles to feed. The swelling needle bases develop into a compact mass and form the pineapple-shaped gall with many individual cells, each inhabited by many aphids. In late July or August, the cells open and the aphids escape. These escapees deposit the eggs producing the individuals which live through the winter.

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Cooley Spruce Gall Aphid: Galls caused by the Cooley spruce gall aphid occur on Colorado blue spruce, Sitka spruce, and Engelmann spruce. The galls are somewhat larger than those caused by the Eastern spruce gall aphid and occur on the tips of twigs. The growing gall varies from light green to dark purple. It may be 1 to 2" in length and ½ to 3/4" in diameter.

The life history of this aphid, when it remains on spruce, is similar to that of the Eastern spruce gall aphid. However, some of the mature aphids emerging from a gall in July or August fly to Douglas fir to lay eggs. The eggs hatch into young aphids which live during the winter on fir and produce a new brood in the spring when growth appears. These feed on the new growth and may cause some distortion but do not form galls.

CONTROL

MATERIAL	WHEN TO TREAT	REMARKS
60 or 70 sec oil or oil + ethion[1]	Before buds break in mid to late April	crevices of bark or tips of twigs and base of buds on Norway and white spruce for Eastern Spruce Gall Aphid and on blue spruce and Douglas fir for Cooley Spruce Gall Aphid
carbaryl (Sevin) or malathion or endosulfan*	Same as above	same as above

[1]Do not use on blue spruce as it will discolor it.

*Restricted use pesticide in N.H.

SUMMARY

	Eastern Spruce Gall Aphid	Cooley Spruce Gall Aphid
1. Damaging Stage:	Young and Adult	Young and Adult
2. Plant Parts Attacked:	New Needle Mass	New Growth
3. Overwintering Stage:	Immature Female	Young on Doug. Fir or Immature Female on Blue Spruce
4. Number of Generations Per Year:	One	One
5. Time of Year When Damage Done:	Early Spring-Summer	Spring-Summer
6. Number of Applications Per Year:	One	One

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law.

3/76/5C-es

James S. Bowman
Extension Entomologist

COOPERATIVE EXTENSION SERVICE

University of New Hampshire

Pest Fact Sheet

No. 47

PESTICIDE APPLICATOR TRAINING

ORNAMENTALS

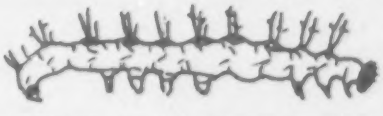
LEAF FEEDING CATERPILLARS

INTRODUCTION

The term "caterpillar" is generally used to describe the larvae of moths and butterflies. They come in a variety of sizes, shapes, and colors, with and without hairs or spines. They differ from sawfly larvae in that they have 5 or less pairs of prolegs on the abdomen which bear crochets (hooks) and the head capsule usually has 6 eyes on each side.

Caterpillars devour the foliage of trees and shrubs, either causing complete defoliation or leaving holes and irregular areas. There are several species that are important pests in New Hampshire.

Spiny Elm Caterpillar (Nymphalis antiopa)



The adult of this caterpillar is commonly known as the morning-cloak butterfly. Full grown caterpillars are black, with white and red dots scattered along the top of the abdomen. The head is covered with tubercles and the body has many large, branched spines. They commonly feed on elm, willow, poplar, and hackberry. The overwintering butterfly lays eggs in the spring and the larvae of the first generation are found in June and early July. A second generation occurs in late summer. The young larvae feed in groups until almost full grown.

Red-humped Oak Worm (Symmerista canicosta)

This species occurs throughout the northeast where it prefers oaks and other deciduous trees such as basswood, sugar maple, paper birch, beech, and elm. The adult is an ash gray moth while the full grown larva has a rounded, orange-red head and a yellowish body that has an orange-red enlargement (hump) on the 11th segment back from the head. The body is also marked with fine black lines on the top and has mottled areas on the sides.

Moths appear from May - July and lay eggs on the underside of leaves. The young larvae feed in groups and skeletonize the leaves. Older larvae feed alone and eat all except the larger veins. Pupation takes place in the ground. There is

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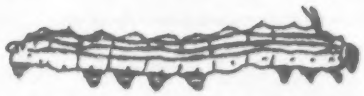
one generation per year.

Green Striped Mapleworm (Anisota rubicunda) 

The preferred hosts of this worm are maples but it will also feed on oak and box elder. It occurs throughout most of the eastern U.S. and the population may become heavy enough to cause serious defoliation. The moth is yellow on top and pinkish beneath with a woolly body. The full grown larva has a cherry-red head, pale yellow-green body and are about 37 mm long. It has seven dark green to black lines running it's length, two slender horns on the thorax and two rows of short spines on each side of the body.

Eggs are laid on the leaves in May and June. The larva feed singly and devour the entire leaf. They become full grown in one month. There is one generation per year in New Hampshire.

Cankerworms (Spring and Fall)

spring fall

The spring cankerworm (Paleacrita vernata) and the fall cankerworm (Alsophila pometerga) are common to the northeast and attack a variety of deciduous trees; but prefer elm and apple. The larvae of the two species occur at the same time of the year and cause the same type of damage. The primary difference between the two species is that the adult moths of the spring cankerworm emerge in April and May to lay eggs, while the fall cankerworm moths emerge in November and December to lay their overwintering eggs.

The larvae of the two species are known as inchworms, measuring worms, or loopers. They vary in color from green to brown but can be distinguished in that the fall cankerworm has 3 pair of abdominal legs while spring cankerworms have 2 pair. The female moth in both species is wingless.

The larvae feed on the foliage and buds early in the season and can completely defoliate a tree. Two or three years of defoliation can kill a tree.

CONTROL

Most leaf feeding caterpillars are easily controlled by spraying with carbaryl, methoxychlor, or malathion when the larvae first become active.

Applications for cankerworms should be made in May when the leaves are developing. Treatment should be made in June and July for the spiny elm caterpillar, red-humped oak worm and green striped maple worm.

SAFE USE OF PESTICIDES

Stop!!! Read the label on every pesticide container each time before using the material. Pesticides must be applied only as directed on the label to be in compliance with the law. Open windows and ventilate the rooms while using pesticides. Avoid inhaling dusts or sprays. Never smoke or eat while spraying or dusting. Do not allow children near you when applying pesticides. Wash and clean up after using pesticides - change clothes if any pesticide was spilled. Dispose of empty containers safely. Bury 18" deep in an isolated area away from any water supply or place in a trash container. Do not burn aerosol cans. Store pesticides in their original containers in a locked cabinet or shed away from food. Be sure tops or caps are on tight. In case of an accident, follow label directions and call a physician immediately.

3/76/5C-es

James S. Bowman
Extension Entomologist

POWER SPRAYERS, POWER DUSTERS, AND AERIAL EQUIPMENT FOR PESTICIDE APPLICATION

Power Sprayers.....page 1
Power Dusters.....page 9
Aerial Equipment.....page 11

POWER SPRAYERS

Four classes of power-spraying and dusting equipment are used on farms:

- -Hydraulic sprayers
- -Air sprayers
- -Fog applicators or aerosol generators
- -Dusters

Models of these are available in several types and sizes. Some units are designed for specific spraying or dusting operations, and some are general-purpose units.

HYDRAULIC SPRAYERS

Hydraulic sprayers discharge the spray by the direct action of a pressure pump on a liquid spray material. The pressure forces the liquid spray through nozzles, which break it into droplets of the proper size and disperse them in the desired spray pattern.

Hydraulic sprayer units can be purchased complete or can be assembled from component parts. Five general classes of hydraulic sprayers are commercially available:

Small general-use sprayers
Multiple-purpose farm sprayers
High-pressure, high-volume sprayers
Low-pressure, low-volume sprayers
Self-propelled, high-clearance sprayers

COMPONENT PARTS

Different spray jobs call for different spraying pressures, different kinds and amounts of spray materials, and different methods of application. Therefore, in buying or assembling a sprayer, particular consideration must be given to the type and size of pump, the size of the tank, the method of agitating the spray material, the type of distribution system, and the nozzles.

PUMP

The pump (with other components) determines the spraying pressure and spraying capacity of the sprayer and the kinds of spray materials that can be handled. The types of pumps are compared in the chart on the following page.

The type and size of pump needed depends on the spray job. Some jobs are done best with low-pressure and high-volume spraying. Others require high pressure and low volume. The size of the job--the number of acres, plants, or trees to be sprayed--is an important factor.

COMPARISON OF SPRAYER PUMPS AVAILABLE

Type	Materials Handled	Durability	Operating Range (rpm)	Capacity in gallons/min at zero psi (approx.)	Maximum pressure in psi (approx.)
Roller.....	Almost any (with proper rollers)	Spraying pressure decreases with water, but worn rollers are easily replaced.	300 to 1,000	1 to 35	250 to 350
Piston.....	Any	Long life	100 to 600	1 1/2 to 60	800 to 1,000
Centrifugal..	Any	Long life	1,200 to 3,500	0 to 120	200
Diaphragm....	Any	Long life	200 to 1,200	1 to 10	100
Gear	Oil emulsions and non-abrasives. Not for wettable powders, except when gears are of nylon.	Limited life under adverse conditions. Spraying pressure and capacity decreases with wear.	500 to 1,800	5 to 20	100
Flexible impeller...	Wettable powders, mild abrasives.	Moderate	500 to 1,500	0 to 30	50
Sliding vane rotary....	Limited to oil and oil emulsions.	Spraying pressure and capacity decreases with wear.	500 to 600	5 to 20	125

Spraying recommendations vary with different crops, and may even vary for a particular crop. For example, on one crop, two different systems may be necessary:

Disease control might require spraying pressure of 200 to 400 pounds per square inch (psi) and an application rate of 75 to 150 gallons per acre (gal/A), and weed control may require spraying pressure of 40 to 80 psi and an application rate of 10 to 20 gal/A.

TANK

Sprayer tanks may be made of metal or fiberglass.

Factory-assembled sprayer units usually have a metal tank, coated inside with a chemical-resistant material. The tank usually has rounded corners inside to facilitate cleaning.

On farm-assembled units, the use of one or more 55-gallon drums is common. This reduces the cost of the sprayer, but the drums are more difficult to clean and usually less resistant to rust and chemicals than are tanks designed especially for sprayers. The drums may be mounted horizontally or vertically on a tractor or trailer.

Sprayer tanks should have a large covered opening in the top, fitted with a removable strainer to make filling, inspection, and cleaning easier. A drain plug should be in the bottom to permit complete drainage when cleaning.

Capacity of the sprayer tank on commercially available units is usually 10 to 20 times the pumping capacity of the pump. For example, a 20-gallon per minute (gal/min) pump would have a 200 to 400 gallon tank.

AGITATION OF SPRAY MATERIAL

The two methods of agitating the spray material in the tank are:

Mechanical--agitation provided by paddles or propeller; and

Hydraulic--agitation provided by the return flow of excess spray material from the pump.

Continuous, positive agitation is necessary in order to use the full range of spray materials. Mechanical agitation is considered better than hydraulic agitation. Excessive agitation of certain solutions and emulsions may cause foaming, heating, or other undesirable results. The label on the pesticide container may indicate the kind of agitation to use.

Mechanical agitation is usually provided with piston-type pumps and engine-run sprayers. Hydraulic agitation is often used with sprayers that have the pump driven by power take-off.

DISTRIBUTION SYSTEM

The four types of spray-distribution units are hand guns, automatic spray heads, spray booms, and boomless nozzles.

Hand guns are used for spraying fruit trees and livestock, for spraying in buildings, and for spraying herbicides along fence rows and industrial rights-of-way. They consist of one or more nozzles in a suitable mounting and a fast-acting control valve. The valve serves as a cutoff and as a means of adjusting the spray pattern. Some guns may have two valves--one for cutoff and the other for adjusting the spray pattern.

Automatic spray heads are sometimes used for orchard spraying. The nozzles are arranged on a vertical boom or series of booms.

Spray booms are designed for spraying field and row crops. They consist of a pipe or tubing on which nozzles are spaced and mounted. (The pipe or tubing can be a part of the system that supplies spray to the nozzles.) Nozzles are usually mounted horizontally on the sprayer and can be raised or lowered. The most common boom lengths for field spraying are 18 and 21 feet. Longer booms 30 feet and more in length are available.

Modified spray booms include single nozzles or sets of nozzles for band and directional spraying. Often one to four nozzles may be mounted on slides, skids, or wheels for controlled differential placement of pesticides in emerged crops.

Boomless nozzle, or broadcast, units consist of a single nozzle or a compact arrangement of nozzles mounted at the rear of a sprayer. They deliver a wide-swath spray pattern to a distance of 18 feet or more on one or both sides of the sprayer. They are less expensive, simpler to operate, and require less maintenance than boom units. However, accurate placement of the spray and uniform coverage of an area are difficult to obtain, because the slightest wind affects the spray pattern. The units are most effective in spraying herbicides along roadsides, ditchbanks, and fence rows. High-gallonage application rates are required.

NOZZLES

The nozzles determine the angle of spray, the type of spray pattern, the spray droplet size, and the rate of discharge.

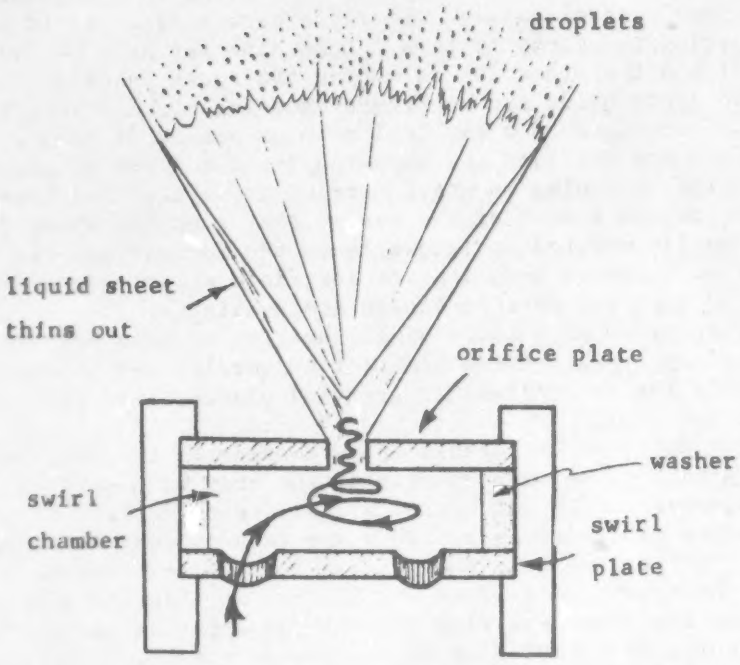
One set of nozzles may be adequate for a field sprayer. The spray pattern and angle and the discharge rate can be varied by changing the replaceable tips or disks. Nozzle manufacturers furnish charts showing the discharge rate of the different tip or disk combinations at different spraying pressures.

Spray pattern may be flat fan, hollow cone, or solid cone. The flat-fan pattern is commonly used for field crop weed spraying. Both the cone and flat-fan patterns are used in insect control.

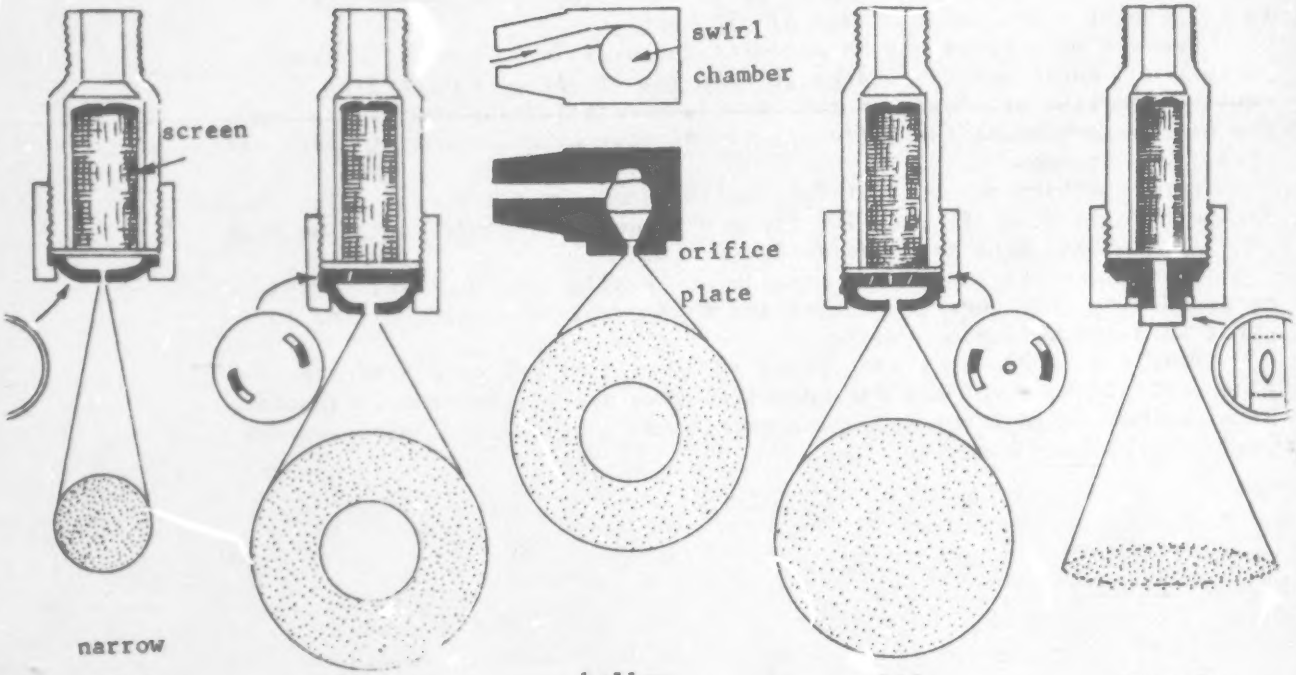
Metal, ceramic, and nylon nozzles are available. Stainless steel, hardened steel, or ceramic nozzles and tips or disks should be used to spray abrasive wettable powders.

Nozzle extensions or drop pipes are available for more accurate placement of the spray and for underleaf coverage in row-crops. Special kits may be obtained for attaching nozzles on a planter for preemergence weed control band spraying.

CROSS-SECTION OF A HOLLOW-CONE NOZZLE



SPRAYER NOZZLE PATTERNS



SMALL GENERAL-USE SPRAYERS

These sprayers include the power wheelbarrow sprayer, the "estate" or small wheel-mounted sprayer, and the small skid-mounted units. The last two are essentially the same sprayer on different mountings.

The sprayers are designed for jobs too large for hand equipment. Jobs for which they are used include garden spraying, small tree spraying, and nursery spraying.

Power wheelbarrow sprayers--smallest of the power-sprayer units--have reciprocating pumps (plunger or piston) that deliver 1 1/2 to 3 gallons per minute and develop pressures up to 250 pounds. Power is supplied by an air-cooled engine of 2/3 to 1 1/2 horsepower. (For greenhouse or other interior spraying jobs, a 1/2 to 3/4 horsepower electric motor can be used to operate the sprayer.) Tank sizes range from 12 to 18 gallons. Spray material in the tank may be mechanically or hydraulically agitated. Standard equipment includes adjustable hand gun and hose. Spray booms are available for some models.

Estate sprayers are small two-wheel mounted units that can be moved by hand. Trailer hitches for moving by vehicle are available as special equipment. Smaller models of these sprayers have 15- to 30-gallon tanks and pumps that deliver 1 1/2 to 3 gallons per minute at pressures up to 250 pounds. Larger models have 50-gallon tanks and pumps that deliver 3 to 4 gallons per minute at pressures of 250 to 400 pounds. Power is supplied by an air-cooled engine of 3/4 to 1 1/2 horsepower. Spray material in the tank is mechanically agitated. Standard equipment includes hand gun and hose; spray booms are available for some models.

MULTIPLE-PURPOSE FARM SPRAYERS

These sprayers are designed to handle all or most of the spraying needs on farms--from low-pressure weed or row-crop spraying (30 to 50 pounds) up to higher pressure fruit-tree, field-crop and livestock spraying (200 to 400 pounds or more.)

The sprayers have plunger- or piston-type pumps that deliver 3 to 8 gallons per minute at pressures up to 800 pounds. Tanks range in size from 50 to 200 gallons. The spray material is mechanically agitated.

Skid-mounted models are powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine. Wheel-mounted models may be powered by an auxiliary engine or by tractor power take-off.

Hand gun and hose are standard equipment; field booms, 20 to 30 feet in length, are available as optional equipment.

HIGH-PRESSURE, HIGH-VOLUME SPRAYERS

These sprayers are used primarily by commercial applicators or growers for truck crops. They provide the high-pressure, high-volume spray delivery required for complete coverage of fruit trees in full foliage and the dense growth of vine and other truck crops.

The sprayers are similar in design to multiple-purpose sprayers, but have pumps and tanks with larger capacities. The pumps deliver 5 to 60 gallons per minute at pressures as high as 1,000 pounds. Tanks range in size up to 600-gallon capacity.

Field booms designed for use with these sprayers may be the adjustable type or of special design for use on one specific crop.

Hydraulically operated one-side booms are often used to reduce soil compaction (caused by the weight of the sprayer) that might injure the roots of potatoes, tomatoes, and other plants.

Hand guns or automatic spray heads are used for fruit-tree spraying.

LOW-PRESSURE, LOW-VOLUME SPRAYERS

These sprayers are designed primarily for 3 to 50 gallons-per-acre application at less than 100 pounds pressure for insect, disease and weed control in crops.

The sprayers usually have rotary-type pumps, and the spray material in the tank is hydraulically agitated. This limits their use to sediment-free spray materials.

Tractor-mounted models consist of a kit of component parts (pump, valves, pressure gauge, pressure regulator, spray boom, and brackets for mounting the boom and one or more metal drums) which mount on the tractor. The pump mounts on the tractor and is operated by tractor power take-off.

Wheel-mounted models may be operated by tractor power take-off or by a separate engine. They may have a conventional sprayer tank of 50- to 250-gallon capacity or one or more 55-gallon metal drums mounted on the trailer frame.

SELF-PROPELLED, HIGH-CLEARANCE SPRAYERS

These special-purpose machines are designed for spraying field and row crops that are too tall for conventional sprayers.

They consist of two basic units--a vehicle (or carrier) and a sprayer. The vehicle may be a tractor modified to clear plants 5 to 8 feet tall or it may be a specially designed, self-propelled chassis.

Units designed around a tractor usually have a multiple-purpose, skid-mounted sprayer, which is attached to the frame. They may have three or four wheels, with the power at the rear wheels.

Chassis-type units usually have a low-pressure, low-volume sprayer, powered by a separate engine. They usually have three wheels, with the power at one front wheel.

The spray boom is usually mounted on the rear of self-propelled, high-clearance sprayers, and it can be raised or lowered to permit spraying of high- and low-growing crops.

FOG APPLICATORS

Fog applicators, or aerosol generators, are not commonly used on field crops because of the type of spray produced. They are used mostly for temporary control of mosquitoes, flies, and other insects outdoors or in buildings and for pest control in green-houses.

The sprayers produce a fog, or mist, that remains in the air. The fog must contact the pest to be effective, since there is little or no residual action.

Outdoor applications are usually made at night when temperature, humidity, and wind conditions are most favorable. An application cannot be made under excessive wind conditions, but some air movement is required to disperse the spray over the area to be treated.

POWER DUSTERS

Power dusters are seldom used. They are usually classified by the method of powering--engine or tractor power take-off. They may also be divided into two general types--single-outlet units (one hose and nozzle) designed for orchard dusting, and multiple-outlet units designed for field- and row-crop work. Power dusters in general have these essential parts: Dust hopper with agitator and adjustable feed regulator, fan, distribution system (hose and nozzles), and power source.

The units available differ in the type and capacity or size of components, method of powering, and method of mounting.

DUST HOPPER

Dusters are available with hoppers that can hold from 2 to 4 cubic feet. Capacity of the hoppers is 60 to 200 pounds of dust, depending on the density of the dust.

Most units are equipped with internal-type agitators.

The feed regulators are adjustable to deliver dust at rates between 5 and 50 pounds per acre.

FANS

Centrifugal-type fans are commonly used on power dusters. The fan case is fitted with one or more outlets, the number depending on the number of hoses attached.

The fans generally operate at speeds of 2,200 to 3,400 revolutions per minute and deliver 500 to 1,000 cubic feet per minute of air at velocities of 50 to 100 miles per hour.

DISTRIBUTION SYSTEM

Fruit-tree dusters usually have one discharge hose and nozzle. Vineyard units have two hoses and nozzles.

Field- and row-crop dusters may have 4, 6, or 8 hoses and nozzles; some may have as many as 18. Outer ends of the hoses are mounted and spaced on a metal boom, 18 to 20 feet in length. The boom can be raised or lowered, and can be folded for transport.

For field-crop dusting, a tubular-type boom, 20 to 40 feet in length, is often used. It may have a series of discharge holes spaced on the bottom side or it may have an adjustable outlet slot.

Accessories are available for more effective dusting. Hose-support rods, for example, permit better dusting of low-growing crops and better underleaf coverage of rows.

MOUNTING

Engine-powered units may be mounted on a tractor or trailer or transported by truck or other vehicle. Units powered by tractor power take-off may be tractor or trailer mounted.

CALIBRATION

Before starting a dusting operation, check the application rate of the duster unit. Dust mixtures vary in density, and the application rate can vary at a given setting of the feed regulator.

Follow this procedure:

1. Measure off an area of at least 1/2 acre (21,780 square feet).
2. Fill the dust hopper and set the feed regulator for the desired application rate.
3. Dust the measured area. Drive at a constant rate of speed, because rate of speed affects the application rate. A tractor speedometer is recommended.
4. Refill the hopper from a weighed amount of dust. Subtract the weight of the remaining dust from the weight of the original amount. This gives the amount required to fill the hopper, and therefore the amount applied to the measured area.

AERIAL EQUIPMENT

(AERIAL APPLICATION MUST BE DONE BY A LICENSED AERIAL APPLICATOR)

The key to successful aerial application of pesticides is UNIFORMITY of the initial spray deposit over the plant canopy. The chemical will be redistributed by dew, rain, or overhead irrigation to other parts of the plant including lower leaf surfaces, stems and fruit. The key to uniform aerial application is the DESIGN and ADJUSTMENT of the spray distribution system and the OPERATION of the aircraft.

The advantages are summarized below. Most important is the speed of coverage to combat widespread and fast developing epidemics when they strike major crops such as corn, cereal grain, potatoes, and vegetables. One aircraft can do more work in an hour than most ground rigs can do in a day. Aircraft can spray fields that are too wet for ground equipment, which is often the case when fungus pests are most active.

ADVANTAGES OF AERIAL APPLICATION

1. Faster
2. Better timing
3. Works on wet fields following rain or irrigation
4. Only feasible way to cope with pest epidemics
5. Eliminates sprayer wheel damage and soil compaction
6. Reduces mechanical spread of virus and bacterial disease
7. Spray deposits resist weathering better
8. Uses less water
9. No runoff
10. Lowers grower's capital investment
11. Reduces labor requirements

DISADVANTAGES OF AERIAL APPLICATION

1. Some fields inaccessible or too uneven for successful flights
2. Inherent potential for environmental pollution and drift damage
3. Certain crops not suited to aerial application

EQUIPMENT AND OPERATION

AIRBORNE-AIRBLAST SPRAYER

To consider an agricultural aircraft an "airborn-airblast sprayer" will put its function into better focus. Its efficiency depends on its adjustment and operation. The airstream from a fixed wing aircraft or helicopter moves outward and downward. The objective is to put the spray into this stream of air in such a manner that it comes out uniformly across the crop when spraying is completed. Swaths must overlap properly. The upper canopy of foliage is a primary target for insects and diseases of most crops. Penetration of vertical distribution will be adequate for most crops, except in unusual situations.

SWATH WIDTH

Most aircraft in calm air will disperse some spray to a width about twice that of the wingspan. The effective swath width is governed mainly by the weight and wingspan. Tight swaths give better lateral surfaces, perhaps even to the undersides of leaves. For most field and vegetable crops, swaths at just beyond the wingspan of 36 to 40 feet for light aircraft and up to 45 feet for heavier craft are suggested. Optimum swath for helicopters is usually 5 to 10 feet beyond the normal boom length.

FLAGGING

Swaths should be marked at the end of the field with permanent flags or by a flagman. Swaths should be measured accurately with a chain or other device except when rows can be accurately counted. Test plots should be at least three swaths wide to avoid mixing of treatments.

SPRAY VOLUME

Experience has shown that the volume of aerial spray can be reduced significantly with no real loss in disease control. Whereas five to ten gallons per acre was considered minimal a few years ago for field and vegetable crops, volume of two and three are now used successfully. This necessitates well-designed and operated spray systems of either boom-nozzle or Micronair types. The water or other liquid vehicle in the spray serves no other function than to keep the mixture fluid until it is delivered to the target on the plant. Only sufficient water is needed to make the chemical sprayable. On vegetables and field crops, two to three gallons of spray volume per acre is considered optimum. Most orchard crops and vineyards can be handled with volumes up to five gal/A. Some very unusually tall or dense foliage crops or situations requiring greater penetration to the lower surfaces may benefit from slightly higher volumes, if aerial application is at all feasible. A slight increase in normal volume may be desirable under unusually low humidity conditions if some type of non-volatile carrier cannot be used. Spray volume is not nearly as important as the uniformity of the distribution of the chemical into the airstream of the aircraft.

SPRAY ADJUVANTS

The initial spread and coverage of the spray can be enhanced with a spreader-sticker on many hard-to-wet crops because they are smooth, waxy, or hairy. Properly chosen, such materials, sometimes known as surfactants, will greatly improve initial retention and will also aid redistribution without excessive runoff. Certain emulsifiable spray oils have also been used to advantage with aerial sprays. They improve spreading, tenacity, and redistribution and tend to reduce the evaporation of the spray in flight.

Ordinary household detergents or herbicide spray adjuvants are not recommended as agricultural spray adjuvants. They may cause too much foam, excessive runoff, and may lower the tenacity of the spray deposit.

TYPE OF AIRCRAFT

Any of the commonly used makes and models of fixed wing or rotary agricultural aircraft will work if they have a good spray distribution system and are operated within their airmoving capacity. This is determined mostly by wingspan, weight, and speed. The aircraft is nothing more than the vehicle to haul the load. The choice will be governed by the type of operation and to a large extent the preference of the operator.

SPRAY DISTRIBUTION SYSTEMS

Boom-nozzle or Micronair Rotary Atomiser sprayers are satisfactory for most fungicides and insecticides. Ultra-low-volume application such as "Mini-Spin" equipment is adaptable to certain insecticides but not fungicides.

BOOM-NOZZLE SYSTEMS

The majority of aircraft are equipped with boom-nozzle spray distribution systems. Either wing-enclosed or trailing-edge booms are satisfactory. Some homemade ones are a "plumbers nightmare."

NOZZLE SPACING AND PLACEMENT

On most aircraft, including helicopters, nozzles must be positioned asymmetrically (irregularly) on the boom, clustered or spread out as required at certain points to compensate for the distortion of the airstream by the propeller or from secondary eddies caused by the fuselage or wheels.

The larger the engine and propeller the greater the distortion will be. Regular or symmetrical spacing of nozzles produces a streaked, uneven pattern except on light, high-winged monoplanes. Many "customized" booms, especially after modifications according to the fancy of the operator, put out a very irregular spray pattern. Factory-installed booms with clustered nozzles as used on "Pawnees" and "Agcats" usually provide a uniform spray pattern. Unfortunately some new models of agricultural aircraft, although they are efficient aerial vehicles, are coming out of the factory with poorly designed spray booms (symmetrical and wingtip nozzles) that will require major modification and nozzle relocation. Most helicopters require minor clustering of certain nozzles to even out the pattern.

WINGTIP VORTICE

All aircraft produce a certain amount of vortice roll at the end of the wings or rotorblades. This can be used to advantage in aerial spraying if the spray released into the entrained air can be kept under control. If the boom is too long on a fixed wing aircraft, too much of the spray may be dispersed into upper air currents where it will be lost and subject to excessive drifting. To prevent this, nozzles should not be used within two to three feet of the wingtip. The so called "high-capacity booms" with nozzles to the wingtip or beyond may be used for high-altitude, wide-

swath, drifting-type application of insecticides to forest trees, but are not recommended for applying fungicides. Similarly, if the boom on a helicopter is too long, some spray will be released beyond the effective force of the rotor tip vortices. Helicopter booms should be only a few feet longer than the span of the rotors.

NOZZLE TYPE

Hollow-cone nozzles such as Spraying Systems No. 4664 Diaphragm TeeJet fitted with a core (whirlplate) and orifice disc are recommended. "Whirl-jet" or flat-fan nozzles are not recommended because they are highly subject to wear and soon produce irregular droplet patterns. Discs and cores of cone nozzles are easily and economically replaced when worn.

NUMBER AND SIZE OF NOZZLES

For spray volumes of 2 to 4 gal/A, 20 to 30 well-placed nozzles are adequate. For volumes of 5 to 10 gal/A, 30 to 44 properly spaced nozzles are suggested. D-4 and D-6 with No. 45 cores are suggested for the lower volumes. D-8 to D-12 with No. 45 or No. 46 cores will be required for the high volumes. The final choice of the number and size of the nozzles depends upon the airspeed, pressure, and volume desired. Preliminary calculations can be made from manufacturer's nozzle capacity charts. Sizes can be mixed to change the output at strategic spots on the boom.

CONTROLLING DROPLET SIZE

The shear forces of the air passing over the face of the nozzles exert a far greater influence on droplet size than the pressure, airspeed or size of orifice used in normal application. The droplet size can be altered considerably by changing the angle of the nozzle into the airstream. The spray volume remains the same with no change in pressure or orifice size.

Nozzles pointing straight down or slightly backward will approximate the desired breakup of the spray for insecticide or fungicide application. Slightly smaller discs or higher pressures may be necessary on helicopters because of the slower flying speeds.

Nozzles pointing forward usually cause too much breakup and create droplets that are too fine and subject to drifting.

The nozzle pointed backward produces a very coarse spray, more subject to streaking and uneven coverage.

Changes in the nozzle angle can be made quickly on the entire boom if it is fitted with a flexible coupling and adjustable mounting. Streamlined or fixed booms that cannot be turned can be adjusted by turning the individual nozzles sideways or downward to the desired angle.

PUMPS AND PRESSURE

High-capacity pumps with one- or two-inch discharge are desirable on aerial sprayers for the relatively high volume and bypass agitation required for wettable powders. Operating pressures usually range between 25 to 50 psi for nozzle systems. With soluble materials or emulsions, less agitation is needed.

MICRONAIR ROTARY ATOMISER

This equipment has been used very successfully with pesticides on a large variety of crops. The individual units consist of propeller-driven rotating wire mesh cylinders. The spray mixture is pumped at low pressure to a central spindle and is discharged by centrifugal force. Droplet size is readily changed by adjusting the variable pitch blades on the units. The faster the rotation the finer the droplets. Droplet size remains relatively consistent regardless of the volume of spray being applied per acre. The delivery rate is altered quickly by adjusting the bypass or flow rate of the pump. The earlier standard model consisted of five rotating cages. The new compact model, AU3000, with two cages, is lighter in weight. It can apply adequate gallonage for fungicides, yet is readily adapted to ultra-low volume insecticide use.

The Micronair Rotary Atomiser produces droplets of a more uniform size than a conventional nozzle. Spray volume of two to three gallons per acre is standard for Micronair and usually somewhat lower than boom-nozzle systems. Four atomisers are suggested for standard aircraft and six for the larger. Operating swath widths are the same as conventional boom systems on a given aircraft. Slightly higher flying altitude is suggested with Micronair equipment to permit full blending of the individual spray streams. Rotary atomizers have a tendency to put out ultra-fine droplets. Operators are cautioned to avoid droplets that are so fine they result in waste and drift hazard. The initial cost of rotary atomizers is higher than a boom nozzle system, but this is offset by economies in operation and maintenance with greater flexibility.

HELICOPTERS

Helicopters equipped with boom sprayers are used successfully for the application of pesticides on a wide variety of crops. They have the distinct advantage of being able to work small and obstructed fields. They do not require airstrips, and considerable ferrying time may be saved. The same gallonage rates recommended for fixed-wing, boom-nozzle sprayers are also recommended for helicopter application. The penetration of dense foliage is excellent with a helicopter at slow to moderate flying speeds. However, at normal operating speeds of 40 to 60 mph, the penetration of foliage has often been overemphasized. It is not necessary except in unusual cases because redistribution of the initial spray deposit corrects the irregularities. Helicopter operators are cautioned not to exceed optimum swath widths and flying speeds for the particular size and weight of helicopter being operated.

CLIMATE AND OPERATING CONDITIONS

WIND

A wind of two to six miles per hour is considered ideal, but aerial applications can be made in steady winds of up to ten to twelve miles per hour with little loss in effectiveness. Suitable adjustments should be made in droplet size under these conditions. Applications should be avoided in gusty winds or during the heat of the day when there are rising thermal air currents. Contrary to popular belief, sprays applied during dead calm and especially under temperature inversions fail to settle properly and may create serious drift problems. For convenience and efficiency, rows are usually planted the long way of the field and flown in the same direction If there is a choice, a light crosswind during spraying is advantageous to equalize the distribution of the spray within the swath and between swaths and should be used whenever possible. In higher winds it may be better to fly up and downwind.

RAINFALL AND DEW

Sprays may be applied when plants are dry or wet with dew, rain or irrigation. Moisture on the plants at the time of spraying helps spread the initial spray deposit. Rewetting the foliage will redistribute the spray. Where permanent or solid set irrigation systems are installed, the water may be turned on for a few minutes to wet the foliage and then shut off before spraying each particular set.

CHECKING SPRAY PATTERNS

THE IMPORTANCE OF PRE-CHECKING EACH AIRCRAFT FOR DROPLET SIZE, UNIFORMITY OF PATTERN, SWATH WIDTH, AND SPRAY VOLUME CANNOT BE OVEREMPHASIZED. THIS MUST BE DONE BY ACTUAL TESTS.

DROPLETS SIZE AND DISTRIBUTION

A reasonably accurate job of checking the spray characteristics of an aircraft can be done on the airstrip. Some dyes will make a good pattern of pesticide particle size and concentration on semi-smooth finish or sign-stock paper. Highly absorbent composition paper or slick black plastic is not satisfactory. Tapes and strips blow about too much. Cards or small sheets of heavier stock can be stapled or tacked about two feet apart to wood strips and laid across the line of flight. A single pass at normal altitude should be made first. This will show the droplet size range, any gross irregularities in the pattern, and the width or lateral dispersion of the spray. An additional pass on either side at the projected swath width will show the degree and uniformity of the overlap. Corrective changes in nozzle location (uniformity), nozzle angle (droplet size), or swath-width (overlapping) can be made where indicated. Achieving a good spray pattern is largely a matter of trial and error, but pattern studies are necessary steps to accomplish this end.

All airspray equipment should be carefully checked before the active spray season to avoid unnecessary and costly delays or faulty application with improperly serviced and adjusted equipment. Rechecks should be made during the season whenever changes are made in the spray distribution system.

CALIBRATION

The spray volume must be known precisely in order to achieve the proper rate of chemical per acre. Once the swath width is established from the pattern tests and the airspeed is known, further adjustments in volume can be achieved by changing the size of the nozzle discs and whirlplates or the pressure. Manufacturers nozzle specification charts should be consulted to make preliminary selection of nozzles. Calibration may be done by flying over a measured distance or by flying for a given length of time. The details of these methods are given in the following tables.

COMPUTATION OF ACREAGE AND MATERIALS

FORMULA: Acres covered = $\frac{\text{Length of swath in miles x width of swath in feet}}{8.25}$

The number of acres in a swath of given width and length can be determined from the chart below.

Example: An aircraft with a 40-foot effective swath treats a strip one mile long. To find the numb of acres, follow the 40-foot vertical column down until it intersects the 1-mile line. The answer to the nearest tenth is 4.8 acres. For swath widths other than those shown, interpolate or use combinations of the figures shown.

To determine the amount of pesticide required, multiply the acres by the desired rate of application.

ACREAGE CHART

Swath Length (Miles)	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
1/4	.9	1.1	1.2	1.4	1.5	2.3	3.0	6.0	9.1	15.2
1/2	1.8	2.1	2.4	2.7	3.0	4.5	6.1	12.1	18.2	30.3
3/4	2.7	3.2	3.6	4.1	4.6	6.8	9.1	18.2	27.3	45.4
1	3.6	4.2	4.8	5.5	6.1	9.1	12.1	24.2	36.4	60.6
2	7.2	8.4	9.8	10.9	12.1	18.2	24.2	48.5	72.7	121.2
3	10.8	12.6	14.5	16.4	18.2	27.3	36.4	72.7	109.1	181.8
4	14.4	16.8	19.4	21.8	24.2	36.4	48.5	97.0	145.4	242.4
5	18.0	21.0	24.2	27.3	30.3	45.5	60.6	121.1	181.8	303.0

AIRCRAFT CALIBRATION

FORMULA: $\text{Acres per minute} = \frac{2 \times \text{swath width} \times \text{miles per hour}}{1{,}000}$

The chart below shows the rate, in acres per minute, at which spray or dry material can be applied when swath width and speed of aircraft are known. For swath widths or aircraft speeds other than those shown, interpolate or use combinations of the figures shown. To find the rate of flow in gallons per minute or pounds per minute, multiply the acres per minute by the number of gallons or pounds per acre to be applied.

Example: A 100 mile-per-hour aircraft has a 40-foot effective swath. Follow the vertical 40-foot column down until the figure opposite 100 miles per hour is intersected. The aircraft would cover 8.0 acres per minute. If 1 gallon of spray is to be applied per acre, the aircraft should be calibrated to disperse liquid at the rate of 8 gallons per minute. If 10 pounds of dry material is to be applied per acre, the aircraft should be calibrated to disperse material at the rate of 10 x 8.0, or 80 pounds per minute.

ACRES-PER-MINUTE CHART

Speed M.P.H.	30' Swath	35' Swath	40' Swath	45' Swath	50' Swath	75' Swath	100' Swath	200' Swath	300' Swath	500' Swath
75	4.5	5.2	6.0	6.7	7.5	11.2	15.0	30.0	45.0	75.0
80	4.8	5.6	6.4	7.2	8.0	12.0	16.0	32.0	48.0	80.0
85	5.1	5.9	6.8	7.6	8.5	12.7	17.0	34.0	51.0	85.0
90	5.4	6.3	7.2	8.1	9.0	13.5	18.0	36.0	54.0	90.0
95	5.7	6.6	7.6	8.5	9.5	14.2	19.0	38.0	57.0	95.0
100	6.0	7.0	8.0	9.0	10.0	15.0	20.0	40.0	60.0	100.0
110	6.6	7.7	8.8	9.9	11.0	16.5	22.0	44.0	66.0	110.0
120	7.2	8.4	9.6	10.8	12.0	18.0	24.0	48.0	72.0	120.0
130	7.8	9.1	10.4	11.7	13.0	19.5	26.0	52.0	78.0	130.0
140	8.4	9.8	11.2	12.6	14.0	21.0	28.0	56.0	84.0	140.0
150	9.0	10.5	12.0	13.5	15.0	22.5	30.0	60.0	90.0	150.0